SOLAR ACCESS FOR NEW YORK CITY

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SOLAR ACCESS STUDY FOR NEW YORK CITY

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Ref.: From report, "Waterfront Revitalization," Dept. of City Planning

INTRODUCTION

This study, undertaken through the Coastal Energy Impact Program (CEIP), arose as the result of the growing national interest in energy conservation generated by the 1970's energy crisis. The study examines the feasibility of using solar energy as an alternative energy source, reducing the city's reliance on foreign oil, and alleviating the building of future power generating facilities which could impact the coastal zone.

The goal of this study is to recommend mechanisms to guarantee solar access and yet allow for the largest possible building bulk on a land parcel without shading neighboring properties during specified times.

The study's primary objective is to investigate solar access potential for new developments in two selected sites within the New York City coastal zone: 1) East River Landing site in Lower Manhattan, and 2) Annadale-Huguenot on Staten Island (See Map I. Coastal Zone Management Map.); and to examine the feasibility of implementation mechanisms to guarantee solar access.

To understand how solar access might be used at these two sites, the following aspects were studied:

a. The evaluation of the opportunities, constraints and cost implications of hot water, space heating and electrical generation solar energy systems as well as passive solar energy (such as sunlight through a window) for residential and business uses;

b. The development of site criteria and methodology to evaluate the solar energy potential of the waterfront sites;

c. Application of the siting criteria and methodology for two sites along the waterfront; and

d. The review of legal alternatives for providing solar access to the two sites under consideration.

A six-phased research project on solar access for two designated waterfront sites was conducted. Section I reviews the solar access literature and defines the terms and concepts used in the methodology developed to evaluate solar access potential. Section 2 sets forth the solar access siting criteria and methodology selected for application to the New York City sites. The two sites are described in Section 3, and the findings of the application of the criteria and methodology are discussed. In Section 4 the economic impact of solar access is evaluated. Legal mechanisms for implementing solar access are described in Section 5. A summary of findings and conclusion follows Section 5. In Appendix I, an inventory of New York City solar energy users and the effectiveness of their solar systems is presented. In Appendix 2 the methodology of constructing solar envelopes is shown in detail.

SECTION I

WHAT IS SOLAR ENERGY?

Solar energy is energy emanating from the sun that is released as it strikes an object's surface. The amount of solar energy that is generated depends on the tilt of the earth, the sun's location in degrees Latitude from the North or South Pole, and the earth's topography. Solar energy radiation can exist in two forms -- beam or diffuse. Beam radiation refers to direct sun rays that produce shading patterns as the sun rays strike an object. Diffuse radiation does not emanate from a point source, i.e., the sun, but is the residue of reflected solar energy from clouds, earth and water.

Solar energy is generally collected by active or passive solar systems. Active solar collectors intercept the solar radiation but require other sources of energy such as electricity to distribute and store the collected heat. A common example of an active system is a roof-mounted solar collector covered with glass that allows water or air to flow through the collector to a storage system, such as a hot water tank, which holds the solar heat. Another example of an active system is photovoltaic cells that convert solar energy into electricity.

Passive solar collectors are those parts of a building which absorb solar heat directly or indirectly without the use of another energy source. An example is sunlight passing through a glass window and producing heat by striking an interior wall. Passive solar energy is commonly found in a south-facing room with ample window area and enough bricks or concrete in the walls and floor to absorb and retain the heat from sunlight. One common passive solar technique involves the construction of a greenhouse or a sunspace on a building's southern exposure. The greenhouse functions in the same fashion as the collector in an active solar energy system; the heat is collected, absorbed and stored for use in the greenhouse to make it energy self-sufficient. A sunspace is physically similar to a greenhouse, but it provides heat to adjacent areas in the building. The greenhouse and sunspace are glass-enclosed rooms or balconies with sufficient "thermal mass" (i.e., the bricks or concrete) to absorb and retain heat. If there is insuffient thermal mass, overheating occurs.

WHAT IS SOLAR ACCESS?

Solar access is the legal mechanism that ensures sunlight will reach a building for a designated period of time without obstructing sunlight to adjacent properties.

HISTORY OF SOLAR ACCESS

Using solar energy to provide heat is not a new concept. Years ago, houses in New England were strategically situated to take advantage of the sun's energy for heating purposes. In the middle of this century, however, as abundant and cheap energy sources became increasingly available, buildings and communities were developed without regard to solar energy.

Today, with the increased cost of conventional fossil fuels, interest in the use of the sun's heat is reemerging. However, the value of solar facilities that harness solar energy diminishes as access to direct sunlight is decreased.

One of the first guarantees of solar access was contained in the English common law doctrine of "ancient lights" which held that windows of private residences that had access to sunlight for a given period of time created a presumptive easement of light in perpetuity. The first serious investigation of solar access as a tool in planning began with research on the design of school buildings in the 1880s. Maurice Javal, a French opthalmologist, proposed that school buildings be set within a protective zone which limited adjacent structures to a distance twice their height from the school buildings to assure access to sunlight. Other studies followed, many proposing mechanical methods for assessing and requiring adequate provision of daylight to schoolrooms.

In 1923, utilizing the results of a number of these studies, J.M. and Percy Waldram elaborated a method for measuring and predetermining daylight illumination within buildings. The analytical method they devised was the precursor of the Waldram diagram, which is simply a means of measuring the effect of building configuration on the amount of light and air penetrated to the street. The Waldram diagram is drawn in a vertical format (See Figure 6.). The Waldram diagram has been made a part of the bulk regulations for zoning in Midtown Manhattan and has long been in use in town planning in Great Britian.

In the last two decades, numerous researchers have examined the issue of solar access. William A. Thomas of the American Bar Foundation, Chicago, Illinois, extensively reviewed laws pertaining to solar access and drafted model legislation in 1978.[1] Thomas' model legislation provided legal alternatives for cities and counties to enact solar access through covenants, easements and zoning. Gail Boyer Hayes wrote the SOLAR ACCESS LAW book which is the most thorough reference on solar access; she updated Thomas' research by expanding upon his concepts.[2] Ms. Hayes' research was followed by two workbooks by Martin Jaffe which illustrated how solar access concepts could be used as planning tools.[3] Jaffe's work focused upon low-density solar access. Jaffe repeated solar law definitions provided by Thomas, as Hayes did, but was the first to develop the term "solar pole" and provide clear diagrams of this term, as shown in Figure I. Jaffe used each pole to represent any object above ground that will cast a shadow without shading a neighboring property.

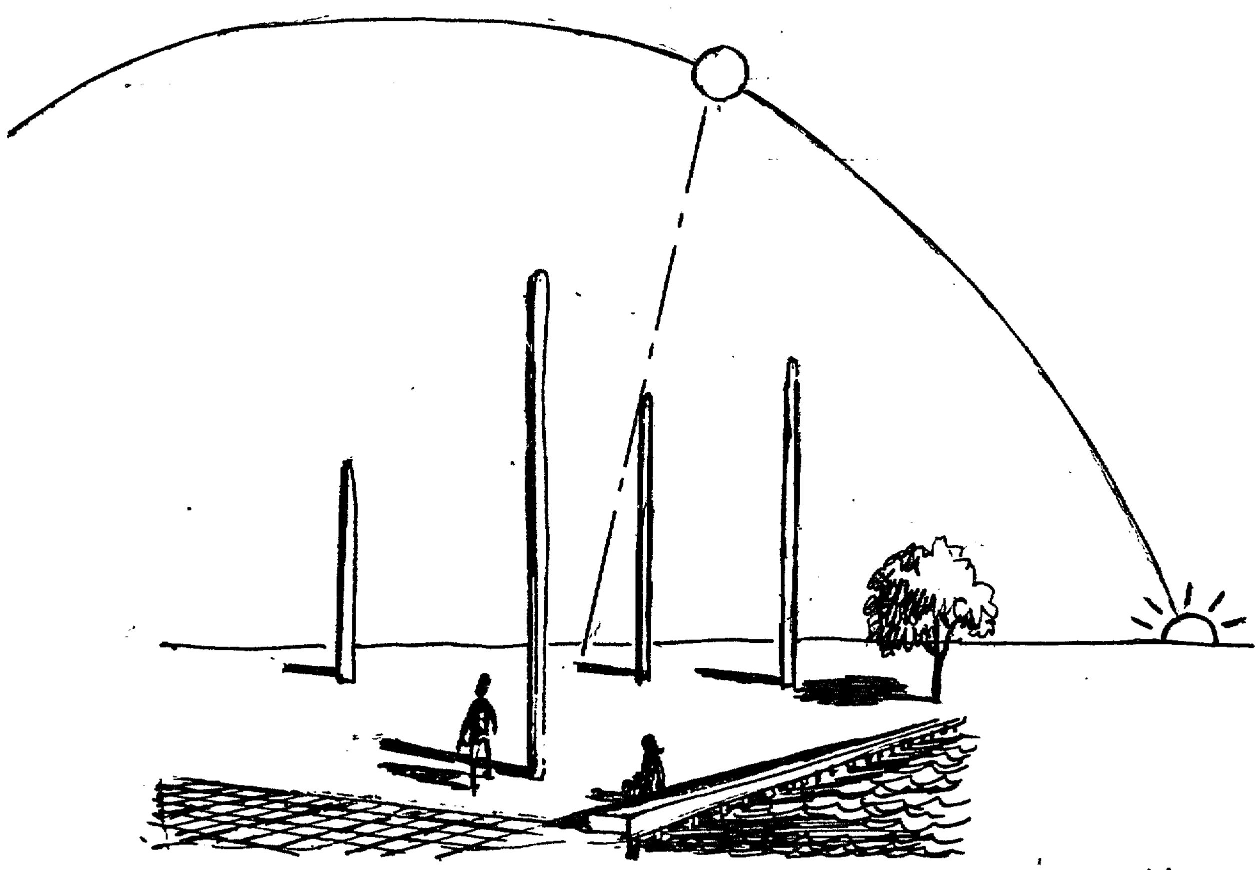


Fig. I. SOLAR POLES WHICH CAST SHADOWS.

In a 1980 report, Ralph Knowles and Richard Berry presented to the City of Los Angeles a new alternative to solar access.[4] They addressed several issues concerning the trade-off between development potential and solar access protection for moderate-density commercial and residential development. This report concluded that closely spaced structures will not shade each other if properly planned.

Ralph Knowles was one of the first to apply planning criteria to solar access. He developed the concept of the solar envelope for use as a tool for site analysis at the Univeristy of Southern California between 1969 and 1971, and published in ENERGY AND FORM in 1974.[5] A solar envelope is defined as the maximum volume which can be built upon a property within which a building will not shade adjacent lots or buildings. Knowles' impact has been in low-to medium-density urban areas such as Los Angeles, which implemented the solar envelope as a zoning and design mechanism in a medium-density area, the Park Mile Plan Study area.[6]

A study conducted in 1981 by Stuart White *et al.* found an abundance of solar access opportunities in New York City.[7] The city has many south-facing walls along streets that run in an east-west direction, which create buildings with a predominant southern exposure. South-facing walls present many solar access opportunities because they naturally receive more sunlight than other walls. The study also concluded that conventional high-rises have less heat loss than single-family residences on a per-square-foot basis. Conventional high-rises have less surface area exposed on a per-square-foot basis than free-standing structures and therefore experience less heat loss. Daylighting, the use of sunlight for the illumination of interior spaces, another form of passive solar energy, can reduce the consumption of electricity used for artificial lighting. The

White study suggests that passive solar energy has far more potential than other local solar experts had thought. (For an inventory of active solar energy collectors in use in New York City, see Appendix I.)

In 1984, Oregon enacted enabling legislation for counties to zone for solar access. These counties in turn were permitted to recommend to the cities under their jurisdiction to enact solar access legislation. Over twenty municipalities enacted solar access zoning provisions. Portland passed an ordinance assuring single-family homes access to sunlight on their south walls. In March of 1985, the Oregon Department of Energy published an easy-to-read handbook, entitled THE SOLAR ACCESS TOOL KIT.[8] The handbook included model subdivision zoning and model solar covenants and easements.

Massachusetts created a Multi-Family Passive Solar Program in 1979 which continued through 1983.[9] The program became the national model for construction of passive solar heating and cooling of multi-family buildings because it was the first to go beyond single-family houses.

Recently, a number of simulation techniques, many in use since the early 1970s, have attracted attention for their ability to demonstrate the effect of building configuration on light and air through the photographic manipulation of solid models. One such method is that developed by Peter Bosselmann, the director of the Environmental Simulation Laboratory at the University of California at Berkeley. The Berkeley simulator uses a modelscope which contains a collection of miniature lenses and prisms that allow the scope to be driven through small-scale physical models with video or still cameras attached to produce the perception of traveling through an environment at ground level. The simulator also uses a "solar fan," a plexiglas sleeve that shows where and how buildings cast shadows at different times and in different seasons.[10]

The research by Bosselmann is being used to assist in the implementation of a new ordinance for downtown San Francisco.[11] Bosselmann's work integrates solar access and daylighting for the downtown buildings with other urban design criteria.

In 1983, Brent M. Porter *et al.* studied sunlight and open space opportunities at Greenacre Park, East 51st Street, New York City, in response to a proposal to build a high-rise at 805 Third Avenue. "Before" and "after" sunlight and shading were demonstrated by comparing a scale model depicting the existing conditions at the site with a scale model depicting the proposed new development. The results of the simulation were presented by William Whyte at a New York City Board of Estimate (BOE) hearing. The simulation demonstrated that the top four stories of the proposed new high-rise would create excessive shading. Based on this conclusion as well as other factors, the BOE denied the top four stories of the high-rise. On-site photographs taken after the 805 Third Avenue development was completed show the resultant impact and the accuracy of the simulation using a scale model. Without the additional four stories, the sunlight is preserved throughout much of the autumn, winter and spring at lunchtime when the park is frequented by the public. Although the high-rise at 805 Third Avenue blocks sunlight after approximately 2:00 PM, its total impact on solar access is less than what would have occurred had the top four floors been added.

More recently, in May of 1987, a precedent was set when the property owner south of Greenacre Park donated his right to build more bulk on his property by granting an easement to the New York Landmarks Conservancy to protect the park.[12] The donation marks the first use of this type of easement intended to protect and maintain the quality of an urban open space which is very dependent upon sunlight.

These examples of solar access criteria, methodology and implementation found in the literature provide the background to develop an approach appropriate for New York City.

SECTION 2

SOLAR FACILITY SITE CRITERIA AND METHODOLOGY

This section provides the siting criteria and methodology for the application of solar access to selected low- and high-density sites in New York City. The siting criteria is a set of guidelines that are incorporated into a methodology which helps determine the solar access potential of a particular site.

SITING CRITERIA

The siting criteria selected to preserve solar access are: southern exposure, solar window, latitude, topography, structure and bulk, lot and building orientation, street configuration, and shading. All of these terms will be discussed in their relationship to solar access.

Southern exposure -- New structures should have southern exposure to maximize solar energy during the winter months. A southern exposure is necessary to maximize the amount of sunlight received between 10:00 AM to 2:00 PM throughout the year when sun rays provide the most heat measured in BTUs per square foot. (BTU is "British Thermal Unit" which is the standard unit of measure of heat.)

Solar window -- Any solar energy system must "see" the sun. The space between the solar facility and the sun moving in its arc across the sky is called a solar window (See Figure 7 and Figure 8.). It is the solar window, the solar facility's unobstructed view of the sun, that must be protected for the solar energy system to be effective. To compute the necessary solar window for a particular area involves the determination of the sun's altitude at solar noon at the winter and summer solstices when the sun is at its highest position in the sky on the shortest day of the year, December 2l, and at its highest position in the sky on the longest day of the year, June 2l. This determines the highest elevation of the top and bottom curves of the solar window. The sun's position at other hours of the day complete the top and bottom curves.

On December 2l, the winter solstice, the sun is in its lowest position in the sky throughout the day, and structures or trees cast their longest shadows of the year. If on this day solar facilities can be protected from shadows for a six-hour period beginning three hours before solar noon and ending three hours after solar noon, then shadows will not pose problems for solar facilities during the remainder of the year when the sun's altitude is higher.

Solar noon determines the lower limit of solar window for a given location. Solar noon is the time when the sun reaches its highest position and its radiation will be most direct. However, solar noon does not exactly coincide with local time. For example, in New York, the sun rises over the eastern tip of Long Island almost one-half hour before it rises over Buffalo. To find solar noon, simply determine the time halfway between sunrise and sunset. This information can be found in local newspapers.

Low solar altitudes may affect structures in an adjoining area due to long shadows. Therefore, an alternate date in November or January when the sun's altitude is incrementally higher could be used to determine this lower limit and will only slightly limit yearly solar access. The upper limit of the solar window is determined by the sun's altitude at solar noon on June 2l, the summer solstice, and is especially critical when determining whether high, nearby buildings block sunlight.

Once the solar window's upper and lower limits are determined, it is then necessary to determine the eastern and western boundaries of the solar facility which must also be protected. In New York City, solar facilities should be protected from approximately 45 degrees east of true South to approximately 45 degrees west of true South. The availability of sunlight to a solar collector from 9:00 AM to 3:00 PM will establish southeast and southwest solar window boundaries that accommodate approximately 85 per cent of the sun's available energy striking the earth on a particular site.

Latitude -- Latitude, expressed in degrees, establishes the distance north or south of the equator where a particular land area is located and determines the sun's altitude and azimuth angles where solar radiation will be available. Altitude is the sun's position at a point perpendicular above the horizon and measured vertically in degrees. Azimuth is the sun's position from that point dropped down to the horizon and measured horizontally in degrees from true North (See Figure 2.). New York City is located at 40 degrees North Latitude, which is within the feasibility range of receiving substantial direct sunlight, and the shadows cast by building or trees will be less as compared to higher latitudes. At higher latitudes, for example at a location further north, the sun's lower position in the sky will cause buildings or trees to cast longer shadows.

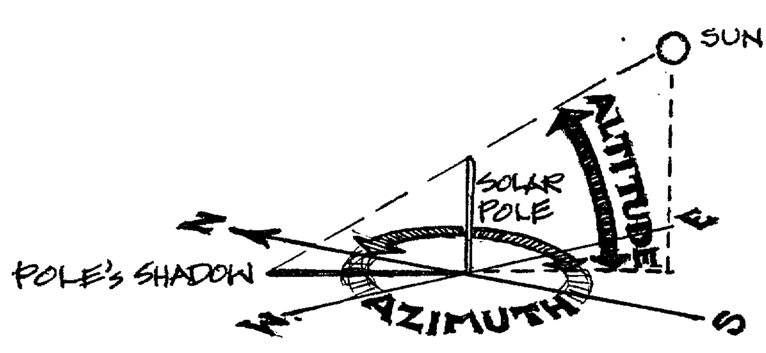


Fig. 2. ALTITUDE AND AZIMUTH.

Topography -- The term "topography" refers to all the physical features of an area including the relief and contour of the land. Topography is important because it affects the amount of solar energy reaching a particular site and affects the shadow lengths that are projected by adjoining structures and trees. Unlike latitude, which is constant, topography is the lay of the land and can cause local variations in available access to sunlight and impingements on sunlight because of the effect of shadow length.

In general, access to sunlight is easier to protect on south-sloping areas, where the land is more perpendicular to the sun rays, than it is to protect on flat areas or on difficult north-facing slopes. Buildings, trees and other objects will cast shorter shadows on south-facing slopes, as seen in Figure 3.

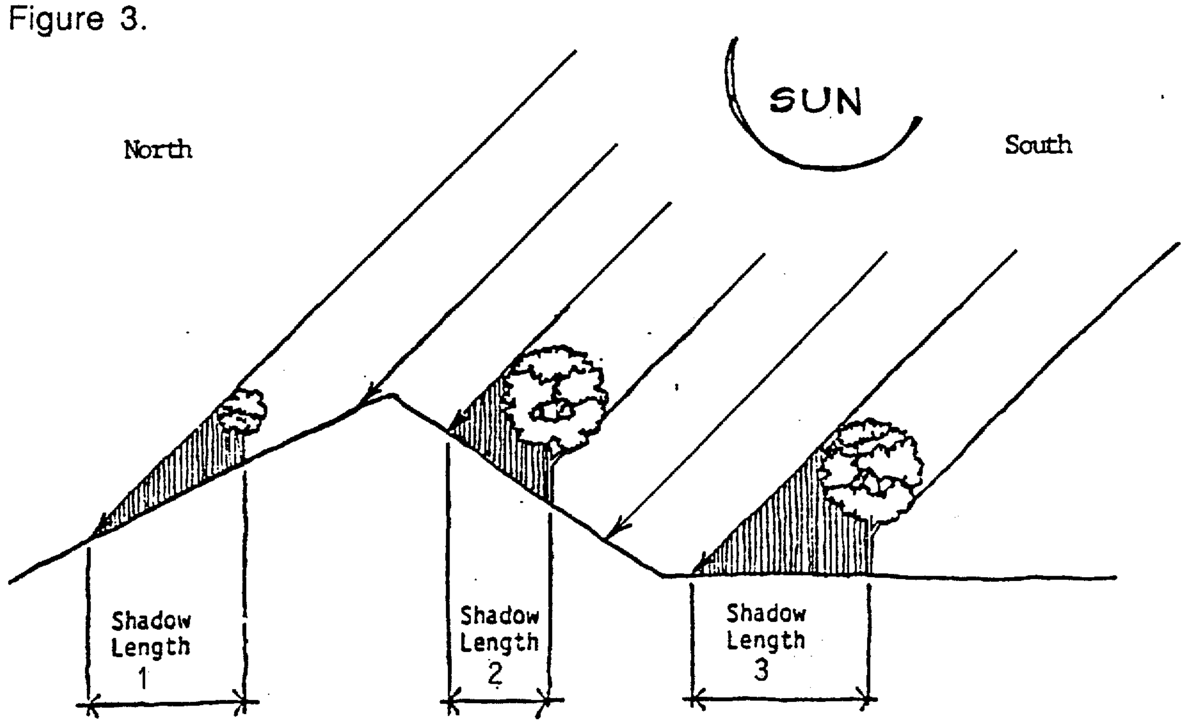


Fig. 3. TOPOGRAPHY AND SOLAR ACCESS

Note: The same size tree will cast a longer shadow on flat areas (3) than on a south-facing slope (2), and will cast a much greater shadow on a north-facing slope (l).

Structure and bulk -- Bulk is the term used to describe the size and shape of buildings or other structures, and their relationships to each other and to open areas and lot lines. Configurations of structure and bulk should be evaluated for their shading effect. Factors that are considered in structure and bulk evaluation for solar access are roof heights, mandatory setbacks, and allowable projections. For example, different roof heights might cause excessive shading to lower buildings, or apartment balconies which are allowed might shade windows which need to receive passive solar energy.

Lot and building orientation -- Individual lots should be designed to accommodate appropriate lot-building relationships. The lots should provide the availability for buildings to be oriented toward the south without shading their neighbors to the east and west. Zoning regulations for rearyards, sideyards or setbacks may limit the flexibility to orient buildings for the best use of solar energy. On larger sites or in special districts appropriate orientation will be easier to accommodate.

Street configuration -- To allow buildings to have long walls facing south, the streets should be oriented in an east-west direction while limiting the number and length of north-south streets.

Shading -- Shading by neighboring buildings must first be considered to see if any impingement on solar access exists. Secondly, trees and shrubs should be sited to maintain solar access. Partial shading of active solar facilities can result in substantial reductions in efficiency. On the other hand, passive solar facilities such as space heating and cooling rely on the effective management of shade; no shade in winter but necessary shade in summer. Deciduous trees, which drop their leaves during the autumn and grow new leaves in the spring, are ideal for this purpose.

Trees located on the southern and western sides of a structure allow substantial amounts of sunlight for solar space winter heating and provide shade for summer cooling.

METHODOLOGY

A comprehensive methodology that incorporates the siting criteria to facilitate solar access for a particular area is the solar envelope.

A solar envelope is the shape which defines the maximum volume which can be built upon a property within which a future building will not shade adjacent properties and buildings. A solar envelope is analogous to a circus tent above a property that restricts the height and shape of the structure underneath it, as seen in Figure 4.

A "modified solar envelope" is a solar envelope which is constrained to allow limited shading to adjacent properties and buildings, a condition brought about by difficult, high-density development conditions.

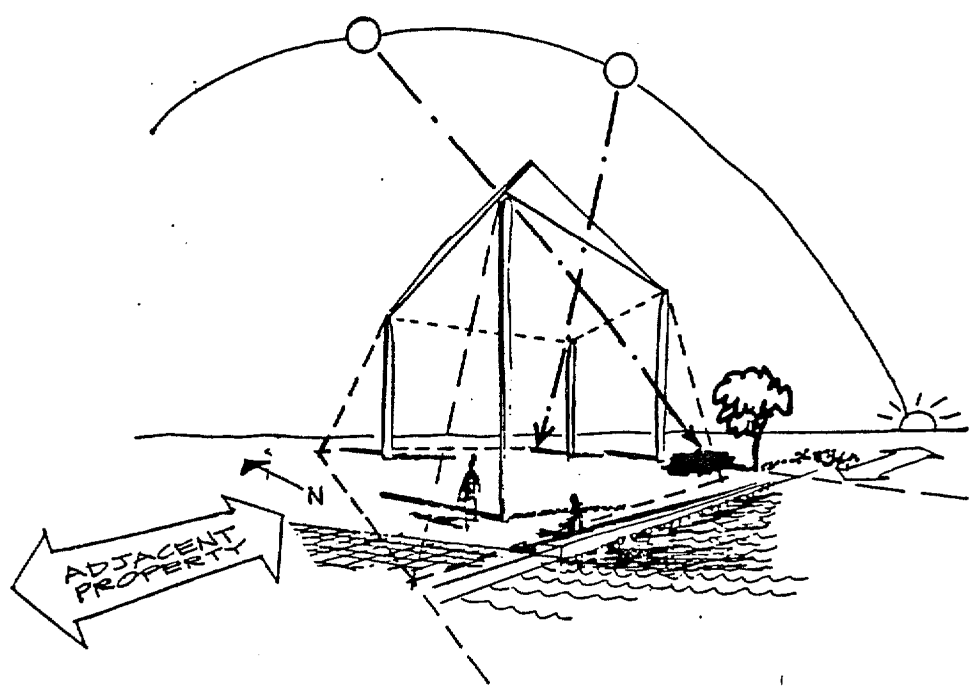


Fig. 4. SOLAR ENVELOPE AS A 'TENT' OVER SOLAR POLES.

The information necessary to construct a solar envelope consists of the positions of the sun over the site for the yearly period; a map of the site including existing roads, existing buildings, adjacent properties, and trees surrounding the site, and the drawing technique.

The tent-like concept of sloping planes to simulate solar access dates back to the bulk plane provisions of the 1916 New York City Zoning Resolution. Provisions attempted to insure adequate light and air for public outdoor spaces and for occupants of buildings. To do this, the bulk of buildings was decreased as the height of the building increased. Setbacks governed the decrease of bulk as a building stepped back from its lot line. The setback angle began several stories above the lot line, but then the angle sloped inward from each lot line along a street. The result was a "wedding cake," stair-stepped building configuration. Thus, the blockage of sunlight was lessened because sunlight could penetrate at the sides of a building and reach other buildings or urban spaces behind. Several new skyscrapers of the period, when examined together as an urban design, in effect create valleys between them. The availability of sunlight, though impeded by the central core of the building, is spread more uniformly because of the "valleys." The drawings by Hugh Ferriss in 1916-1917 gave a bold vision of the potential high-rise volumes which would conform to the angular setbacks (See Figure 5.). Today, the early zoning provisions are reflected in "sky exposure planes." These planes incline at various angles. However, the solar envelope's sloping planes represent a mathematical sum of the sun's rays reaching a site at various times throughout the year. At a given position of the sun, a plane can represent an infinite number of sun rays, side by side, and all striking a site parallel to each other. This is a "solar plane" (See Figure 6.).

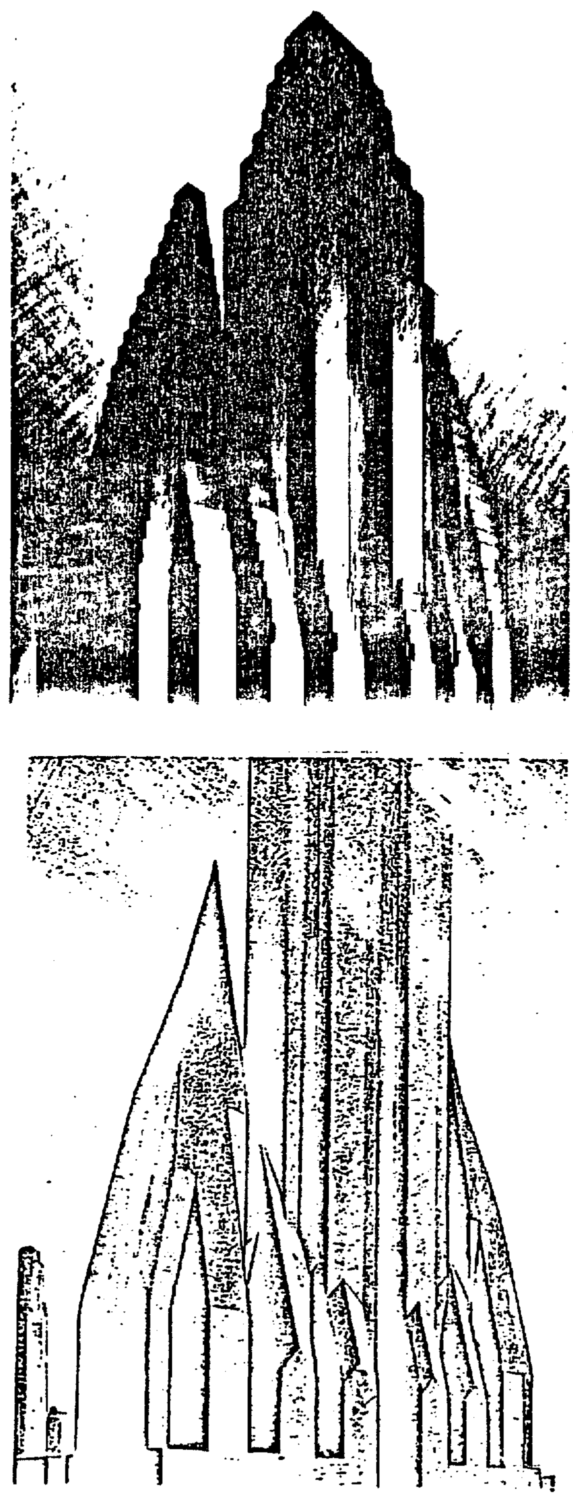


Fig. 5. MAXIMUM MASS DIAGRAMS, HUGH FERRISS, 1916.

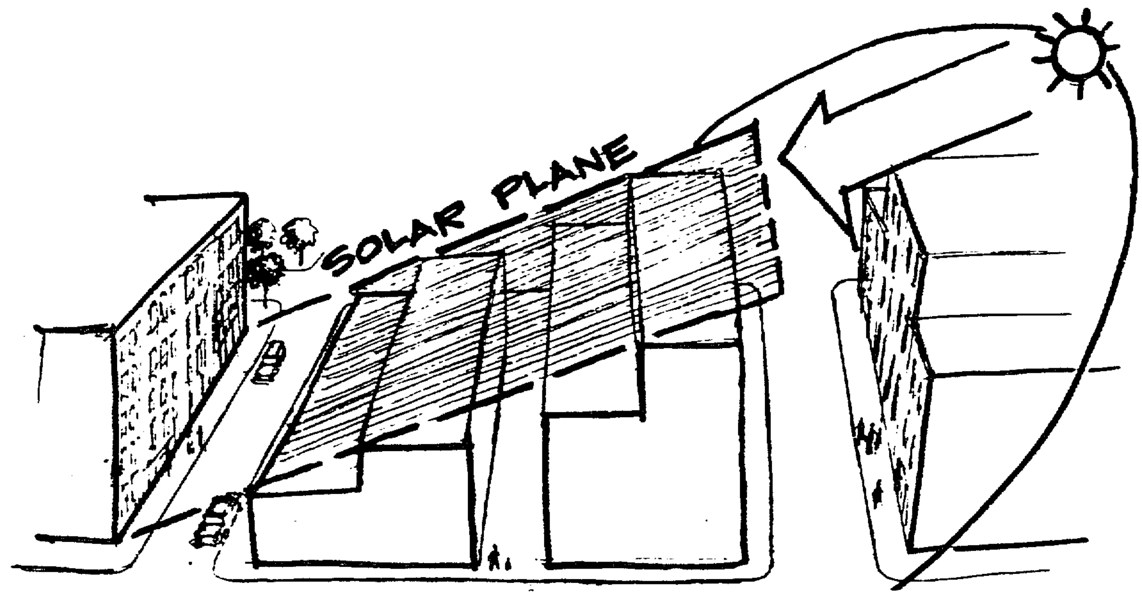


Fig. 6. SOLAR PLANE.

The solar envelope, to work properly, must be applied to all land parcels within a selected district. This approach allows lot owners access to direct sunlight for active and passive solar use.

In developed areas, the infrastructure and shading by existing buildings as well as the compliance with solar planes must be considered to determine developable volume. The solar envelope consisting of the solar planes may cast its shade on streets and open spaces. The "modified solar envelope" may extend its shade on the lower portion of an adjacent building in high-density development areas. Once a solar envelope is generated for a particular site, it maintains a static relationship to the remainder of the local environment.

The envelope configurations are based on known solar angles; thus, it is possible to develop computer programs that can generate solar planes, mathematically add them together, and produce solar envelope volume when lot size and orientation are known. Envelopes for many lots within selected districts could be inexpensive to produce and duplicate graphically.

Solar envelopes should only be applied to sites that currently have access to solar energy and that can benefit from the preservation of sunlight to the site for the future through adequate regulations.

The graphic construction of solar envelopes is discussed in Appendix 2.

SECTION 3

APPLICATION OF SITING CRITERIA AND METHODOLOGY

The siting criteria and methodology developed in Section 2 were applied in two selected sites in the Coastal Zone, Annadale-Huguenot and East River Landing. These two sites were selected as potential areas for solar access because of their southerly orientation, unobstructed solar access, lack of development on-site, and their location within the boundaries of the coastal zone. The Annadale-Huguenot site in Staten Island is a low-density residential area in the middle of a l,080-acre former urban renewal area. The second site, East River Landing in Lower Manhattan, will contain a mix of high-density residential and commercial development built on a decked structure along the FDR Drive.

SITE EVALUATION

Preliminary site evaluation using a "sun chart" (Figures 7 & 8) can determine whether a solar envelope should be drawn.

The sun chart shows an eye level view of trees and buildings that will block part of the available sunlight. For example, as seen in Figure 8, a structure blocking direct sun rays to the property at a particular part of the day will appear as a protrusion within the frame of the "solar window." Photographs taken at each corner of the property and corners of adjacent properties will record the preliminary site evaluation of the availability of direct light. No obstacles appeared through the "solar window" on the sun chart for the Annadale-Huguenot and East River Landing sites.

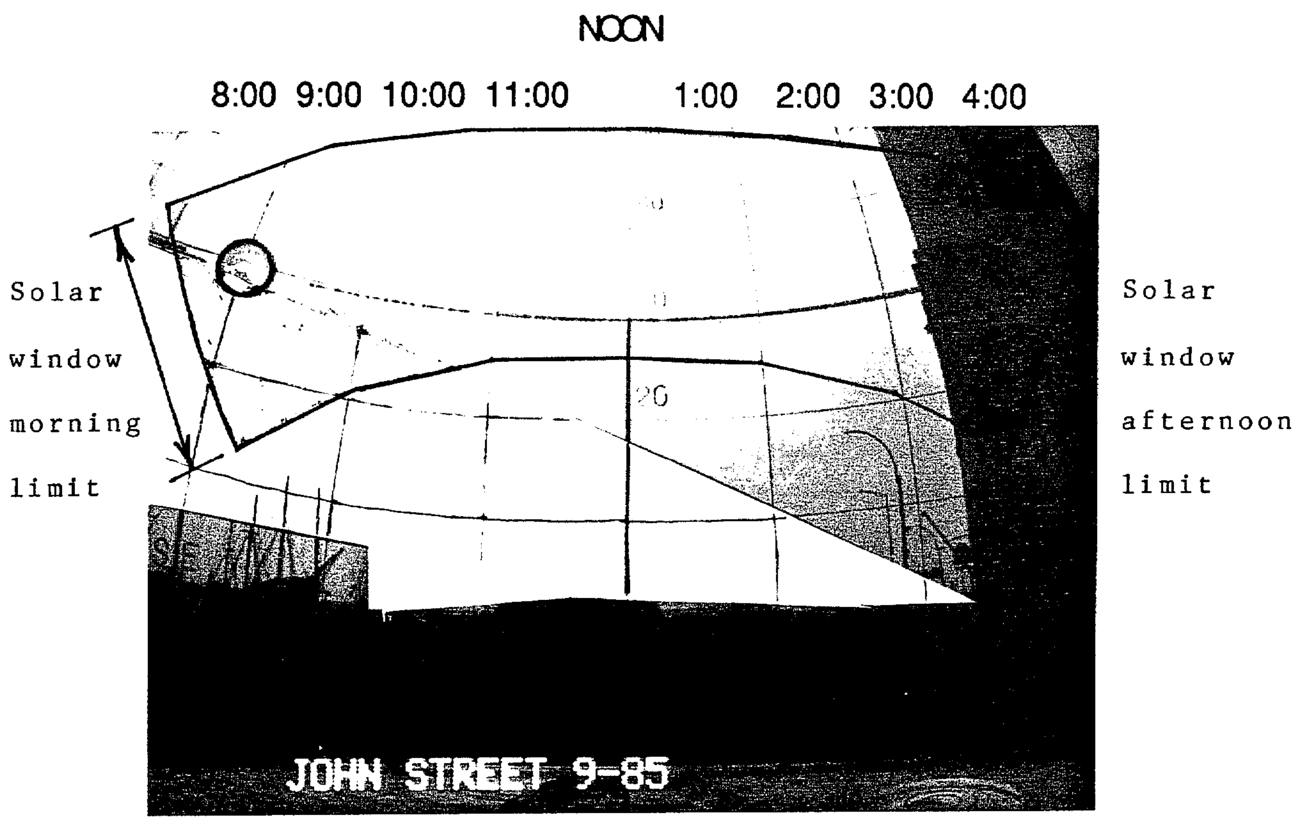


Fig. 7. SUN CHART WITH SOLAR WINDOW PARTIALLY BLOCKED.

A solar window is documented by means of phoptography. As Figure 8 shows, a photographic apparatus is needed which will allow the camera to record the sun chart at a correct scale within the photograph taken at the site.

This process is similar to other methods for establishing the position of the sun in relationship to a given site. Following the British example in which the Waldram diagram was used, similar methods were developed in the United States in the l940s through the l970s (See Figure 9.). Whereas the Waldram diagram shows how sunlight strikes a vantage point by presenting the sun's movement in a vertical plane, Americans tended to show the same information projected on a hemisphere. The sun's movement from a given vantage point is drawn on the hemisphere as if a windshield wiper had swept the surface. Libbey-Owens Ford Glass Co. produced a widely used tool, the Sun Angle Calculator, which in effect flattened the hemispherical projection to a flat, horizontal plane. More recently, the sun chart method has brought the return to a vertical format, except the sun's movement in relation to a vantage point including that of a camera is curved from east to west similar to the "windshield wiper" diagram of the hemispherical projection.

In all methods, the positions of the sun in the sky are accurate, but these positions are plotted differently. Emphasis is placed upon access to sunlight at the given vantage point spanning from morning until afternoon, particularly for those hours when most of the sun's energy is emitted.

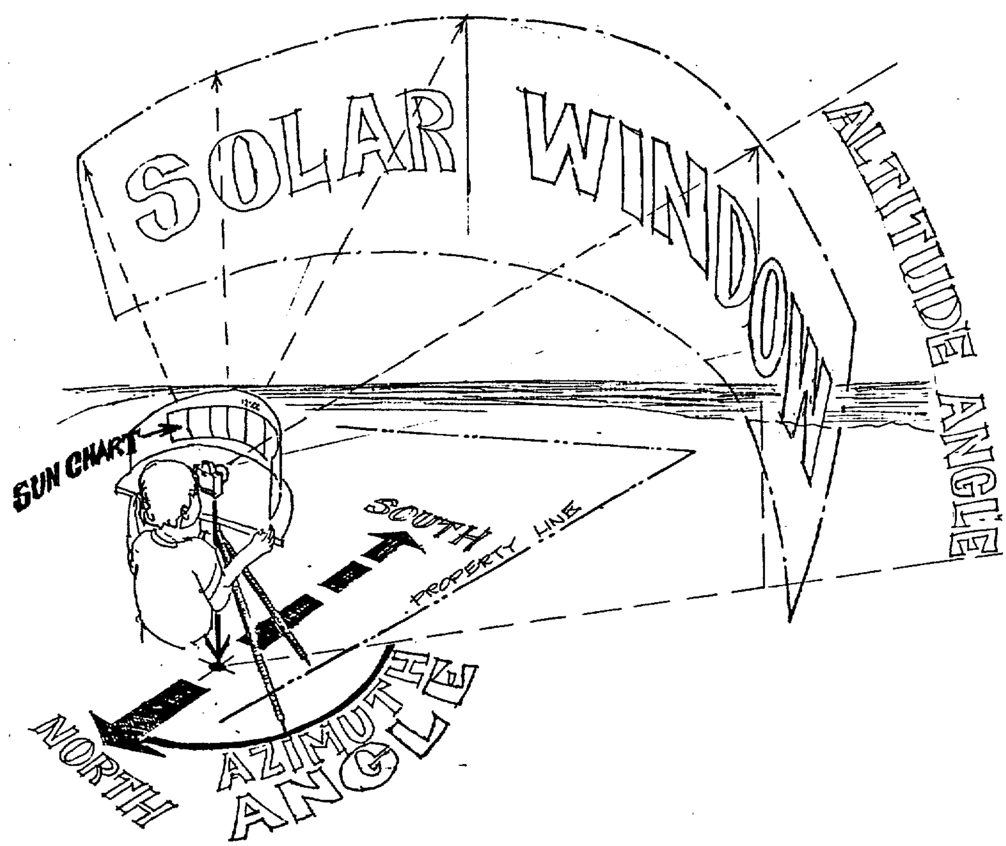


Fig. 8. PHOTOGRAPHING A "SOLAR WINDOW".

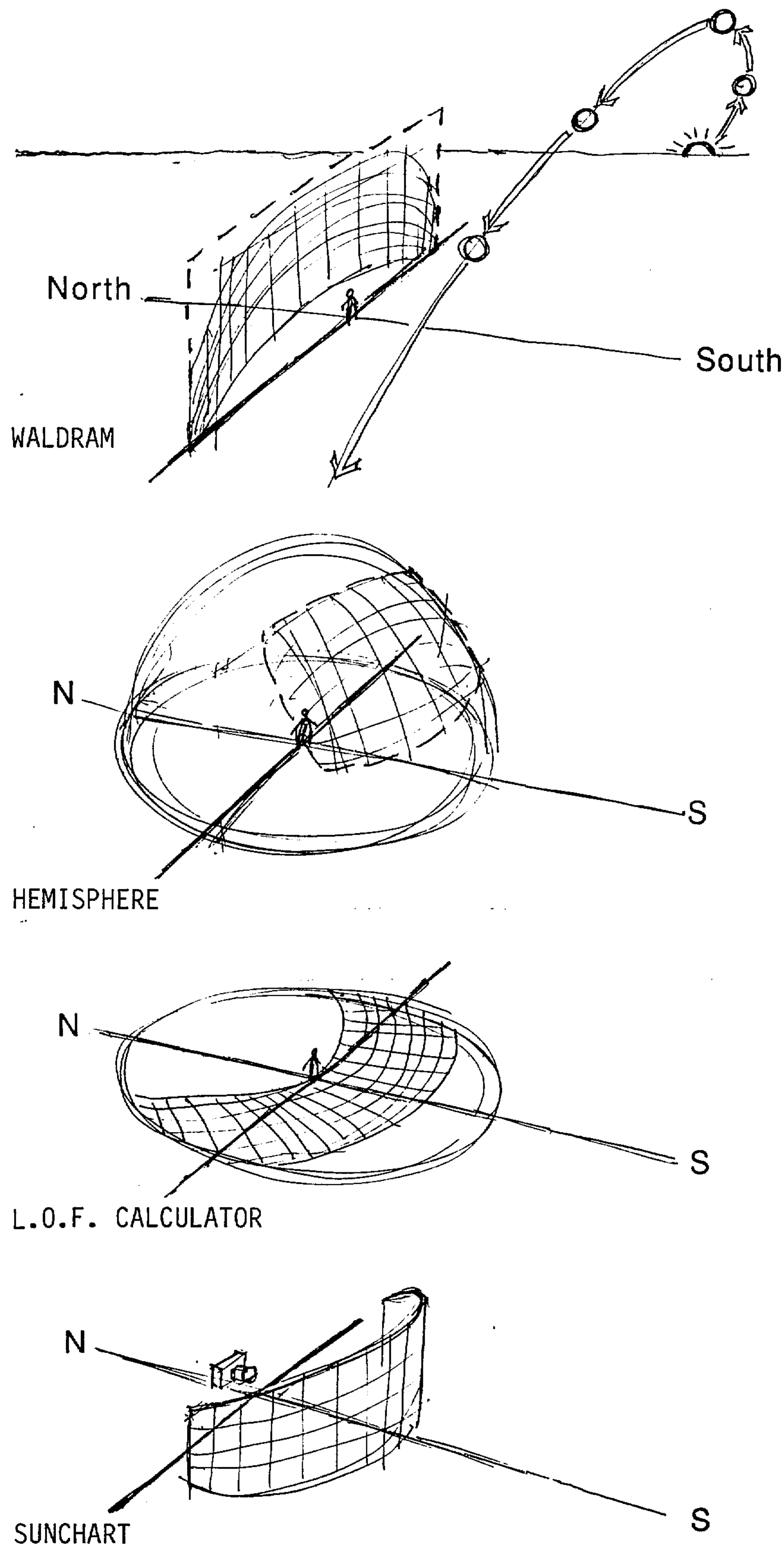


Fig. 9. COMPARATIVE METHODS OF PROJECTING THE SUN'S POSITION. ANNADALE-HUGUENOT SITE.

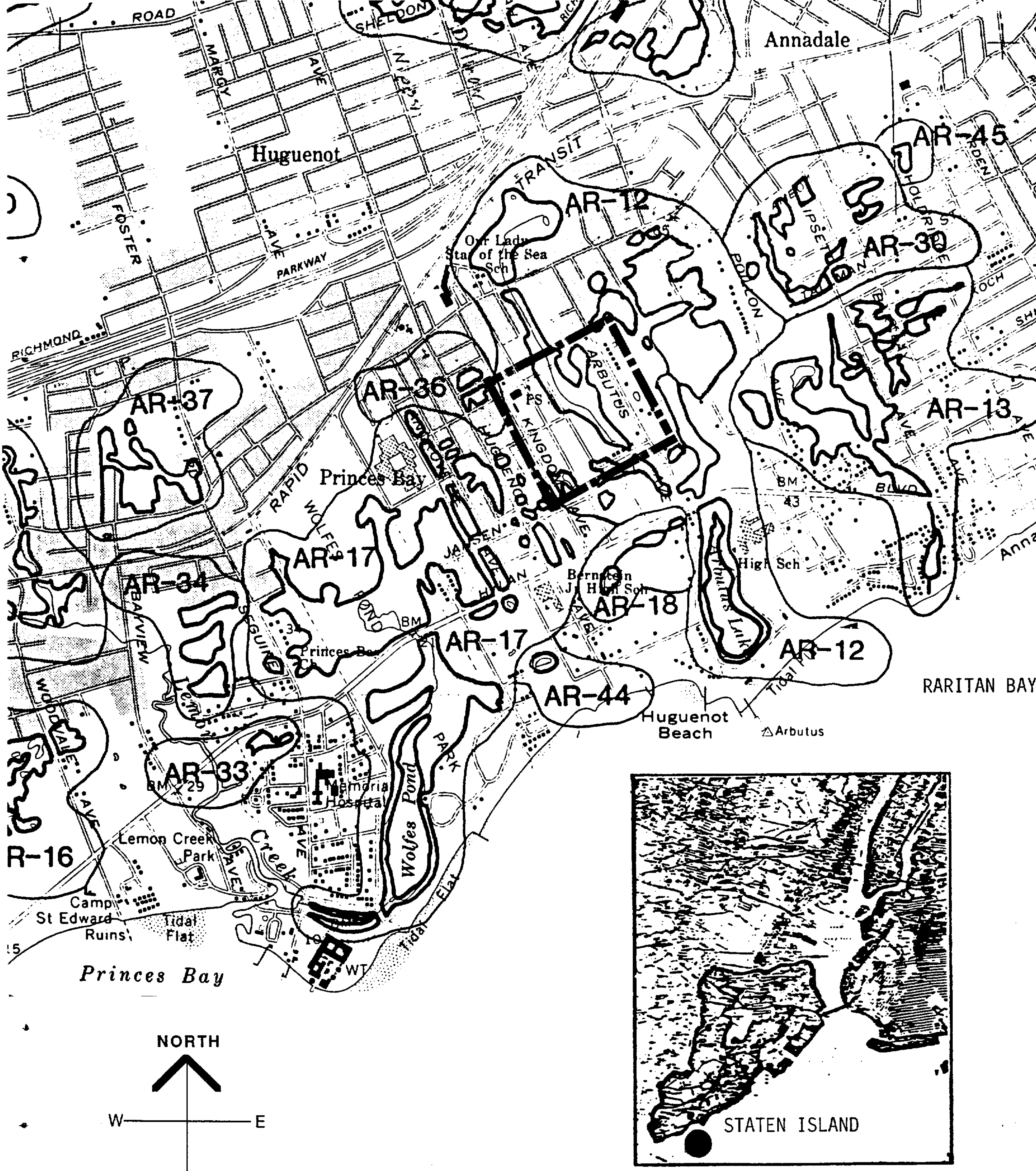
Annadale-Huguenot site

The Annadale-Huguenot area is located in the South Richmond special district of Staten Island and is zoned RI-2 and R3-2 (See Map 2.). The area is bounded by Desius Street to the north, Arbutus Avenue on the east, Louise Street on the south, and Kingdom Avenue on the west. In the site's center are designated wetland areas and open space for passive recreation (See Map 3.).

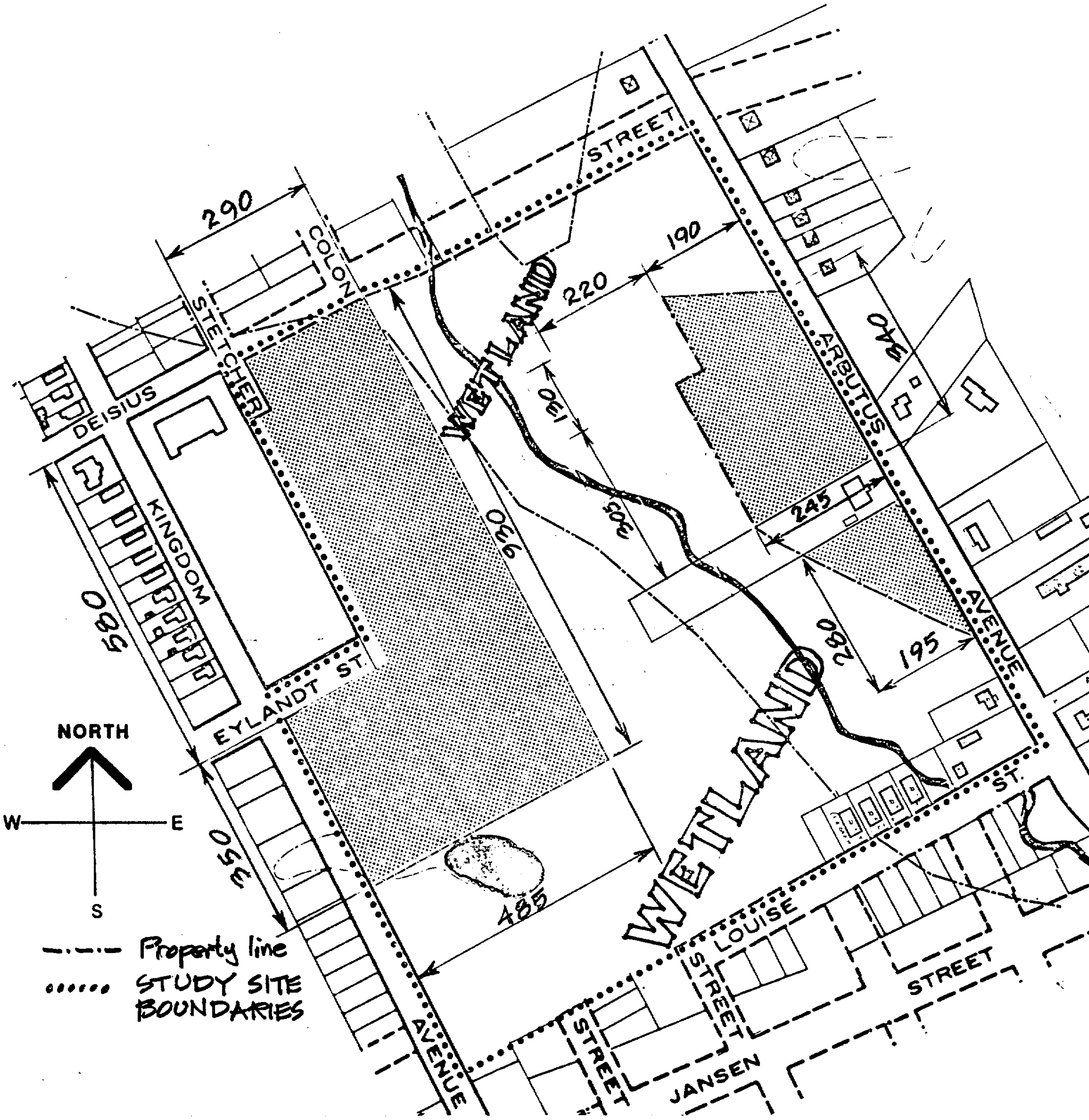
The site has a long history of sporadic development starting in the late 1700's when farmers were attracted to the area for its fertile soil. The construction of what is now called the Staten Island Rapid Transit Line (SIRT) spurred development in the mid-1800's along the railway's right-of-way. Large farms were subdivided into smaller farms, and small villages sprouted over the area. Annadale-Huguenot, never a rich area, maintained a steady economy that was ripe for speculative ventures in the early 1900's.

Land speculators, anticipating an economic bonanza, acquired properties along the expanded and improved SIRT right-of-way. The general economic depression of the 1930's caused many of South Richmond's landowners to default on their property taxes, making New York City the area's largest landholder.

In the 1960's the city realized that some comprehensive economic revitalization plan was needed and established the Annadale-Huguenot urban renewal area in 1969. The plan generally focused on creating affordable low-density residential housing, public access to large open spaces, preservation of freshwater wetlands, and maximizing the natural features of the area for the local and city residents. The designation as an urban renewal area was eliminated.



Map 2. ANNADALE-HUGUENOT, STATEN ISLAND, within Freshwater Wetlands Map for Richmond County, No. 4 of 4, Effective July 23, 1987, Dept. of Environmental Conservation.



Map. 3. STUDY AREA, ANNADALE-HUGUENOT.

SITE CONSTRAINTS AND GUIDELINES

Zoning

South Richmond Special District zoning and underlying zoning are listed below:

For RI-2 Detached type of residence

Minimum lot area:	5700 sq. ft.
Minimum lot width:	40 ft. for I-2 stories 50 ft. for 3 stories 60 ft. for 4 stories
Minimum front yard:	I8 ft. in depth
Minimum side yards:	I5 ft. total width, I-2 stories 20 ft. total width,3-4 stories
Minimum width, side yd.:	5 ft.
Minimum rear yard:	30 ft.
Front wall height:	25 ft. sky exposure plane at I to I ratio (or 45 degrees) above 25 ft.

For R3-2

Three residence types:	Semi-detached	Detached	Attached
Minimum lot area:			
(I-2 stories)	2375	3800	1700
(3-4 stories)	3800	4275	2280
Minimum lot width:			
(I-2 stories)	24	40	18
(3-4 stories)	40	45	24
Minimum front yards:	I8	18	18

	Semi-detached	Detached	Attached
<u>Minimum side yards</u>:			
(l-2 stories)	9	15	10
(3-4 stories)	15	20	10
<u>Min. width/side yard</u>:			
(l-2 stories)	9	5	10
(3-4 stories)	15	5	10
<u>Minimum rear yard</u>:	20	20	20

(with 10 ft. rear setback above the first story)

Other restrictions:	No building shall exceed a height of four (4) stories, and no structure other than the building shall exceed 50 ft.
Front wall height:	25 ft.

In addition to zoning, the following Department of City Planning site guidelines were used:

1. Open space and wetlands must be maintained to the maximum extent practicable.
2. Development must be compatible with the neighborhood character.
3. Street layout is flexible.
4. Underlying zoning is retained.

<u>Topography</u>

The undevelopable parts of the Designated Open Space slopes to the south, while the developable land is flat. Thus, objects cast shorter shadows than if the land was sloping to the north.

Southern Exposure

The dimensions of the developable sections of the study site were arranged on an east-west axis, thus permitting maximum building orientation to the south. The western section of the site has a north-south elongation. It was necessary to arrange the section with east-west access roads to create an east-west orientation for maximum southern exposure. This permits the maximum use of available sunlight for this site.

Solar Window

Sunchart photos showed possible shading from existing trees in the Designated Open Space for both sections of the site. Trees also partially shade existing streets bordering the site. Figures 10 and 11 show these conditions.

Shading

The western developable portion of the site is shaded by trees within the Designated Open Space. The western section receives most of its sun from across the Designated Open Space. The western section receives most of its sun from across the Designated Open Space. Measures were used to minimize shading (See Street Configuration). The eastern developable section of the site is not shaded by Designated Open Space trees because of the section's relationship to the Designated Open Space. Sunlight will strike the eastern section from the west and south and will not have to cross the tall trees in the Designated Open Space to reach this section.

Street Configuration

East-west streets were laid out to maximize southern exposure and minimize shading. Street trees were selected to specifically minimize shading and to be suitable to the soil and water conditions of the site.

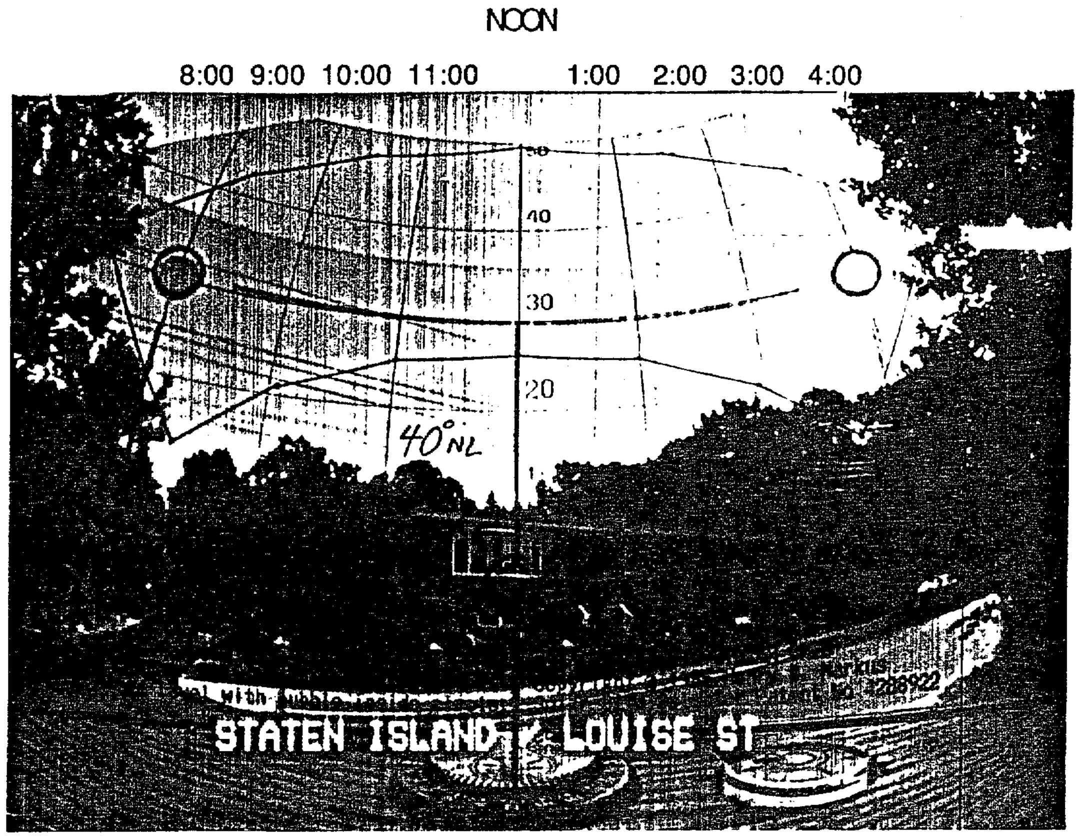


Fig. 10. SOLAR WINDOW, ANNADALE-HUGUENOT SITE.

Sunchart photo at southeast corner of study site.

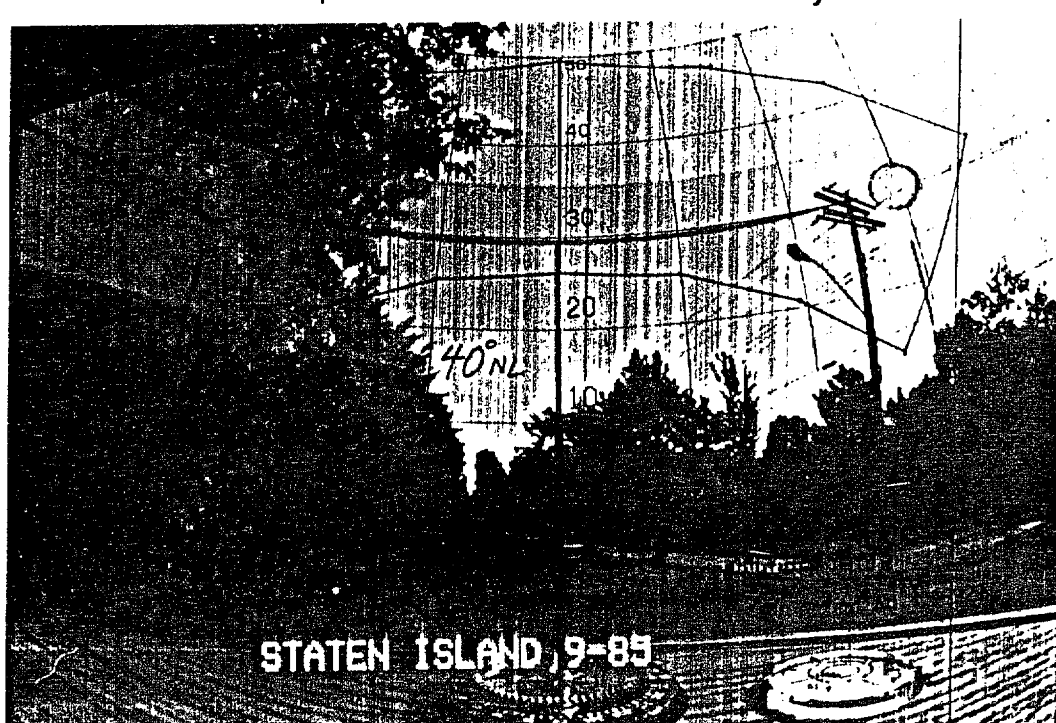


Fig. 11. SOLAR WINDOW, ANNADALE-HUGUENOT SITE.

Sunchart photo at southwest corner of study site.

Structure and Bulk

Buildings should be as low in height as possible to minimize the length and width of shadows. The overall bulk is determined by the solar envelope as constructed to provide the maximum bulk without shading neighboring property (See Appendix 2.).

Parcel Size

The size of parcels was determined by the solar envelope as constructed so that yards and open space catch the shadows from buildings and trees.

Building Orientation

Buildings should be orientated in an east-west direction so that most walls and windows face south. Buildings should be located in the center of the lot farthest from their adjoining neighbors to decrease the possibility of buildings casting shadows on each other. This is seen in the solar envelope. Its four sides slope outward, diminishing gradually as each side reaches the ground (See Figure 12 and Appendix 2).

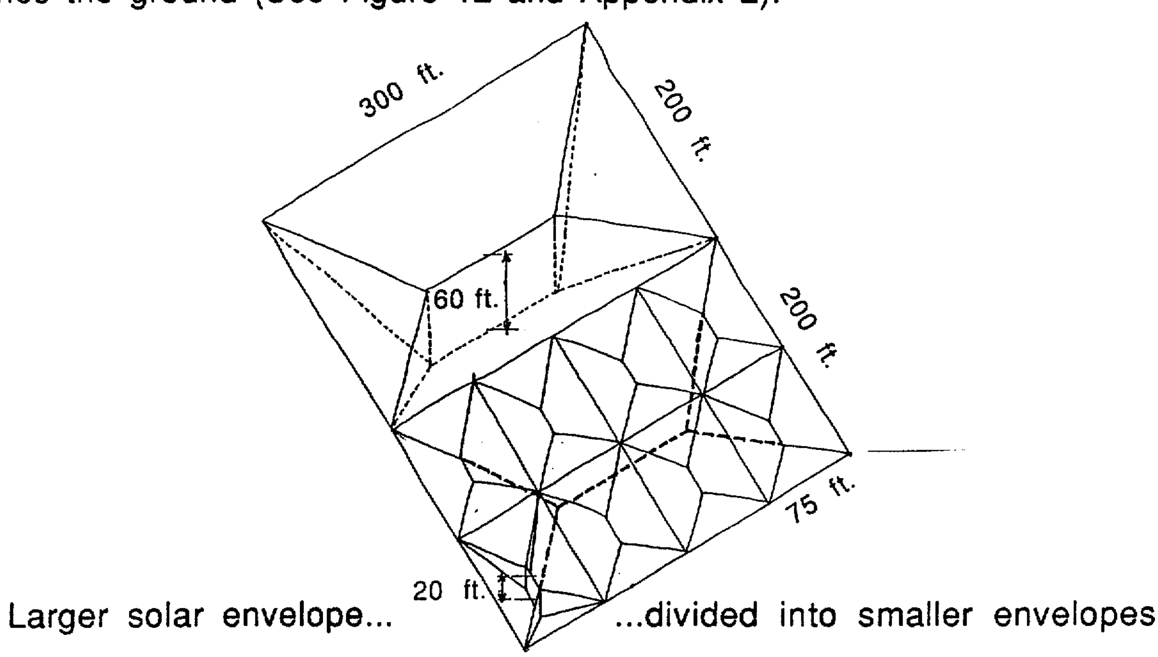


Figure 12. SOLAR ENVELOPES, ANNADALE-HUGUENOT SITE.

APPLICATION

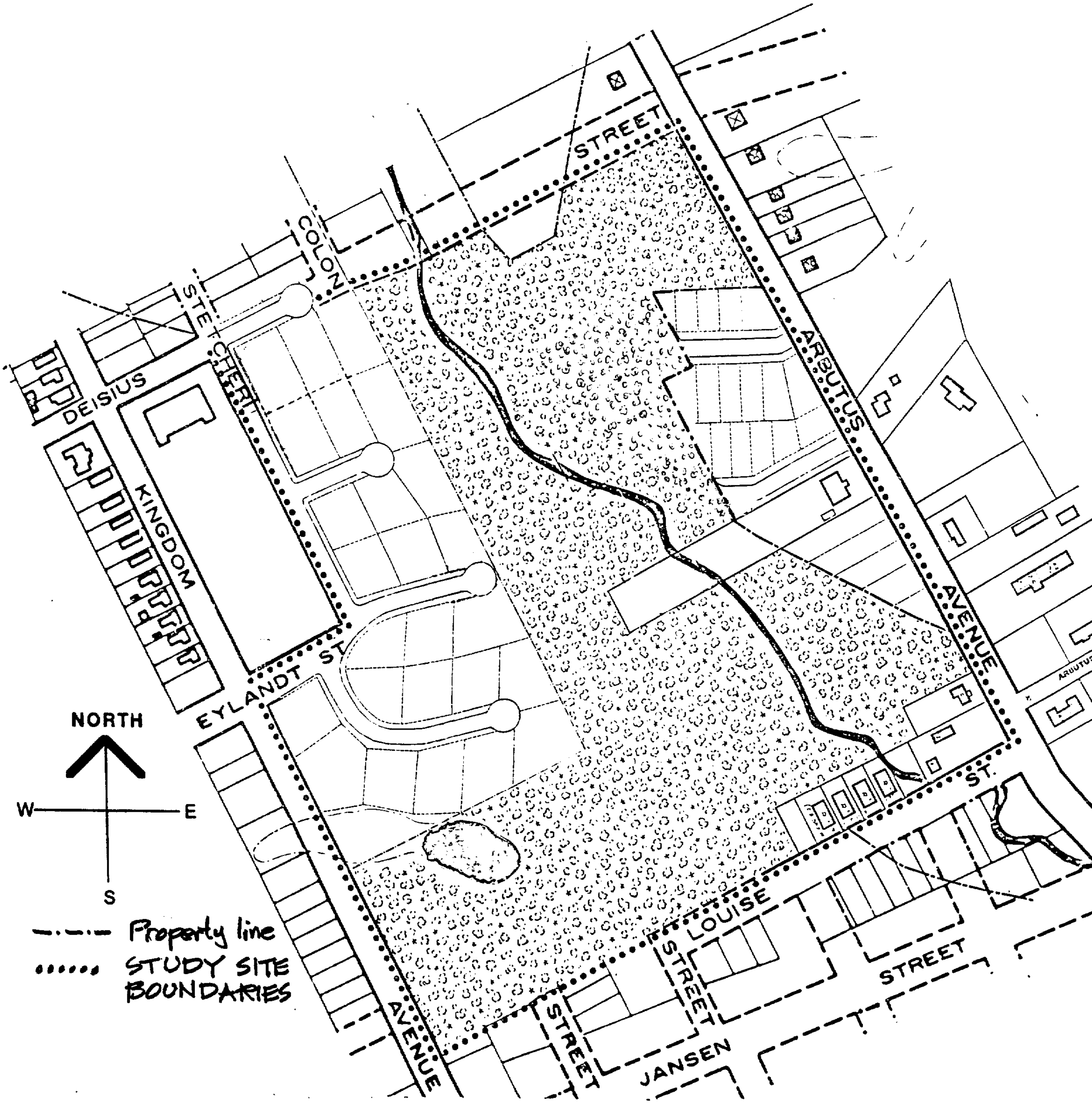
Two site plans were constructed to show possible ways of incorporating all the site criteria and to demonstrate how the solar envelope methodology is applied.

Plan 1

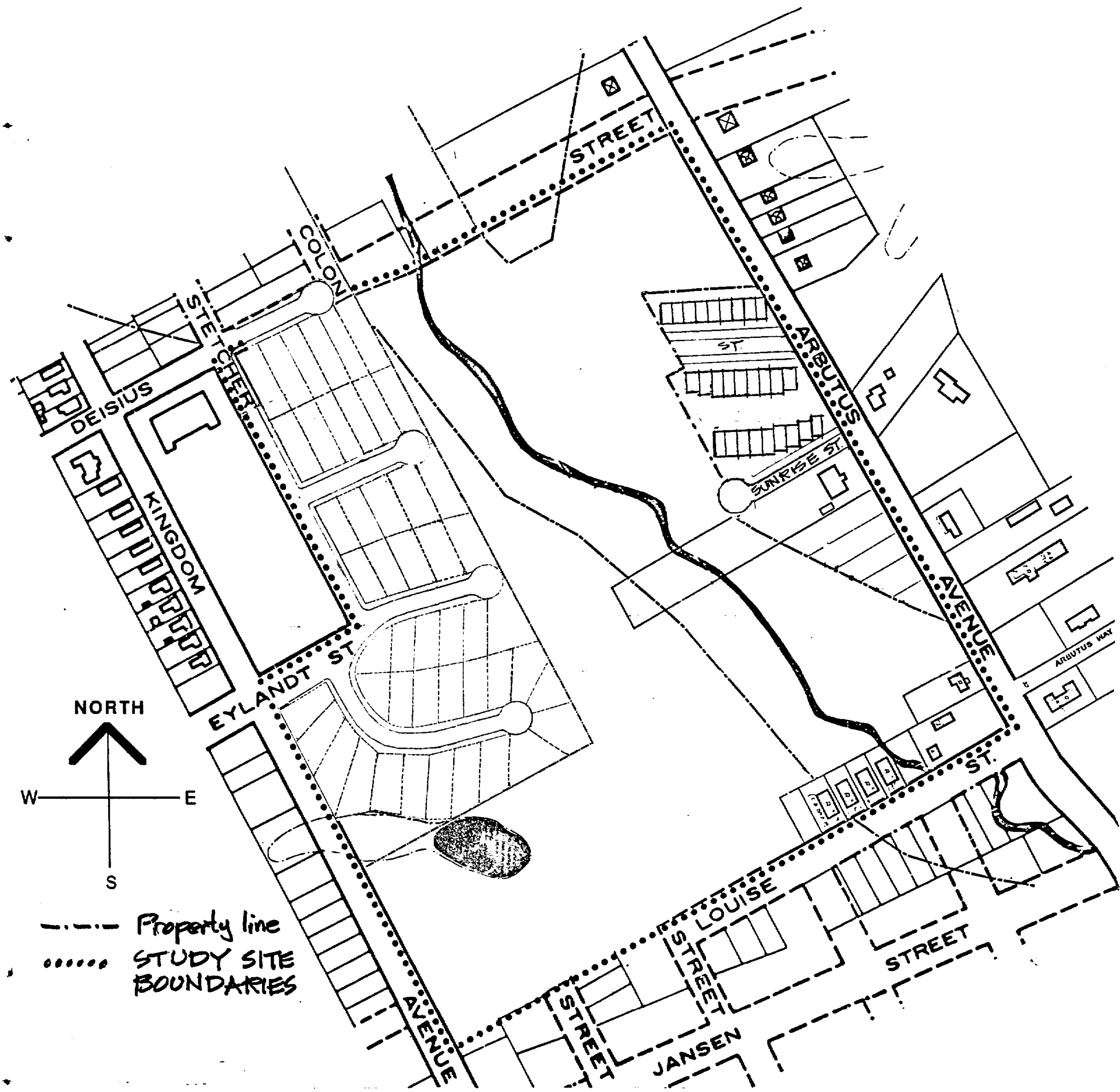
The first plan (Map 4) shows traditional land-use patterns of single-family housing on the west and townhouses on the east. The single-family structures are individually owned, while the R3-2 zoned townhouses are either jointly (co-ops) or privately owned. The lots are configured according to site criteria and other solar envelopes. The streets run in an east-west direction to maximize the advantages of south-facing walls to catch the sun, and are situated to receive the shade of the buildings.

Plan 2

The second plan (Map 5) shows large-scale development by one owner. Building bulk in each zone is shifted or clustered together to create a varied texture that has many benefits. The sharing of exterior walls will reduce heat loss, so less heat will be required to warm the homes. Open spaces and play areas are possible with attached structures. Clustering also results in fewer roads, which increases open spaces and reduces development costs that would in turn reduce housing prices.



Map 4. PLAN 1, ANNADALE-HUGUENOT.



Map 5. PLAN 2, ANNADALE-HUGUENOT.

Common elements in both plans

There are common general elements in both plans. Residences can shade the street or open spaces at any time as long as the shading is not cast on neighboring buildings from 10:00 AM to 2:00 PM.

The specific recommendations for street direction, lot size, building configuration relative to lot size, parking provisions, and control of placement and species of trees for Annadale-Huguenot are as follows:

1. Lots along east-west streets will meet the requirements of the South Richmond Special District. Southern exposure for housing along east-west streets is maximized while maintaining lots 95 to 100 feet in depth. No housing fronts on north-south streets. A short north-south street, Stetcher Street, serves to connect three east-west streets with cul-de-sacs.

2. The cul-de-sacs of east-west streets allow for easy access to the Designated Open Space without crossing private lots.

3. Parking is provided along east-west streets in the R3-2 zoned area. Parking for the R1-2 zoned area (single-family homes) occurs within lots.

4. Current zoning provisions for lot size and yard requirements on a zoning lot located in R3-2 districts may require some South Richmond Development District Sub-Area modifications in order to guarantee solar access and to avoid any shading of one building by another in these districts. The provision that homes are to be constrained by solar envelopes is central to any modifications.

R1-2 Zoned Area

The only change to the R1-2 zoned area is the provision for a 20 ft. front and rear wall height with a setback at a ratio of 1 to 1 (45 degrees) above 20 ft. This provision will assure that a single-family dwelling centrally located on the minimum lot size (5700 sq. ft., with 40 ft. minimum width) will not shade its immediate neighbor's south walls and roof.

R3-2 Zoned Area
South Richmond Special District

No changes to the minimum lot area and the minimum lot width. Changes to yard requirements as follow:

Current provisions	Proposed changes
Minimum front yard of 18 ft.	Minimum front yard of 15 ft. (to allow an increase in the rear yard requirement)
Minimum rear yard of 20 ft.	Minimum rear yard of 30 ft. for 3-4 stories which have a 20 ft. front and rear wall height with a setback at a 1 to 1 ratio (or 45 degrees) above 20 ft.

Below is a list of options available should implementation become appropriate in the Annadale-Huguenot area of the South Richmond Special District of Staten Island. These options are as follows:

1. Establish a condition of sale from the New York City Department of General Services, Division of Real Property, requiring the new property owner to obtain authorization from the New York City Planning Commission coupled with a text change to Z.R. Sections 107-62 or 107-41.

2. Add a text change to incorporate a Sub-Area designation in the South Richmond Special District for the Annadale-Huguenot Study Area including specific yard, building height, and tree type requirements.

Shading by Street Trees

To further insure solar access, only deciduous street trees should be planted in the Annadale-Huguenot Study Area. (The study site lies within the Special South Richmond Development District in which existing trees greater than six inches in diameter cannot be removed. Most existing trees in the study area are deciduous; therefore, their impacts upon solar access will be minimal.) More deciduous trees should be located on the southern side of east-west streets so that shadows will be cast into the streets. Five species are recommended: Callery Pear, Higan Cherry, American Hornbeam, Amur Maple, and Hedge Maple (See Table 1.).

Table 1. SOLAR COMPATIBLE STREET TREES.

special growth conditions												SMALL TREES TO 30'	special growth characteristics										
unique conditions				soil and water					light						ornamental qualities					special uses			
no winds	drought	salt-air	strong winds	alkaline	acid	moist	well-drained	dry	shade	partial sun	sun		evergreen	shape	fall color	flowers	fruit	bark	thorns	for shade	on streets	in planters	rapid growing
●							●			●	●	Cherry, Higan				p	●	●			●	●	
				●	●	●	●	●	●	●	●	Hornbeam, American			r			●		●	●		
			●	●	●	●	●	●		●	●	Maple, Amur			r		●			●	●	●	●
				●	●	●	●	●		●	●	Maple, Hedge									●		
	●	●	●				●	●			●	Olive, Russian		—		w		●	●			●	●
	●		●			●					●	Pear, Callery			r	w					*	●	

Reference: Adapted from "Trees," published by the New York City Department of Planning.

The five species are solar compatible street trees for New York City's coastal climate. Characteristics of each are summarized below:

"Pear, Callery" *(Pyrus calleryana).* The Callery produces an abundance of foliage in May and in the fall, then sheds its leaves in winter and spring, thus allowing sunlight to reach solar buildings. This tree is recommended for streets and windy locations. The tree requires full sun and soil that retains moisture well, although it can withstand drought.

"Cherry, Higan" *(Prunus subhirtella).* A deciduous tree which does not block sunlight in winter and spring, it is tolerant of most soil conditions. As with any tree planted on the street, it should be watered regularly. Like all cherries, it needs a location out of the wind, and at least a few hours of direct sunlight each day. However, it thrives in full sunlight where it produces its best blossums.

"Hornbeam, American *(Carpinus caroliniana).* Also called "Ironwood" or "Blue Beech," this deciduous tree is multi-trunked. The tree is difficult to transplant, grows slowly, and with its multi-trunks may slightly block winter sunlight as compared to other trees recommended. When pruned to a single trunk, it makes a good shade tree in summer.

"Maple, Amur" *(Acer ginnala).* An extremely hardy, deciduous, rapidly growing and relatively pest free tree, it is often used when a small shade tree is desired. It tolerates strong winds, grows in most soils and prefers a sunny or partially sunny location.

"Maple, Hedge" *(Acer campestre).* When it is desired to place a tree on the street and it is to be located immediately north of a building, this tree is a good alternative. It will thrive in full sun but will grow where only partial sun is available. Its dense foliage in summer provides a hedge or screen. It transplants easily and grows in all but the most extreme soil conditions.

A sixth tree and alternate selection for any of the above street trees is the "Russian Olive" *(Elaeagnus angustifolia).* It is multi-trunked, with slender trunks, limbs and branches. It is usually pest free and tolerant of drought, strong winds and salt-air conditions. The Russian Olive grows quickly in a sunny location. Ref.: Adapted from "Trees," *op. cit.*

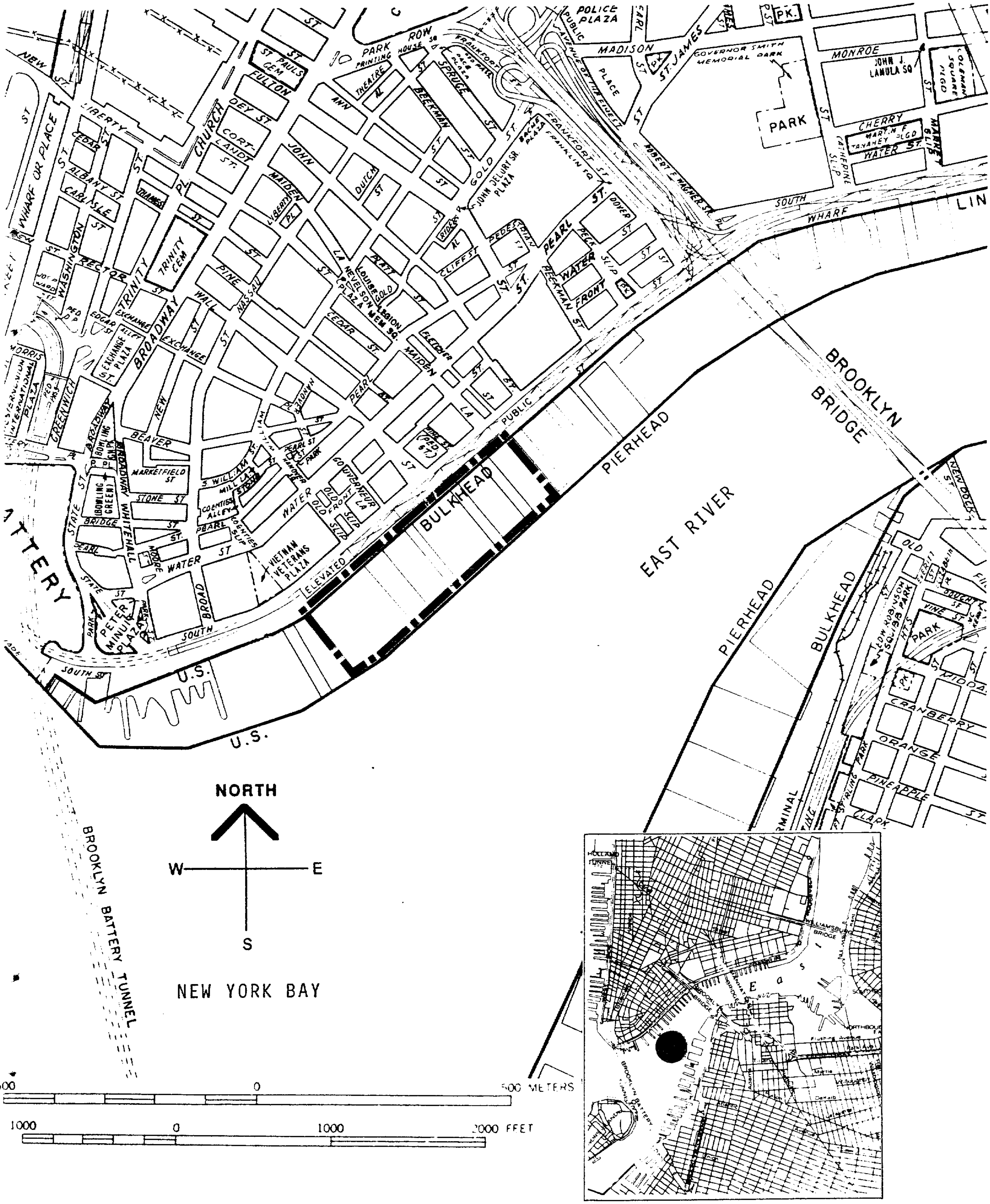
East River Landing site

The East River Landing is in the Special Manhattan Landing Development District. The area is bounded on the north by Maiden Lane and runs 1600 ft. along the waterfront to the Port Authority heliport. The landing will extend 600 ft. into the East River from the current bulkhead (See Maps 6 and 7.)

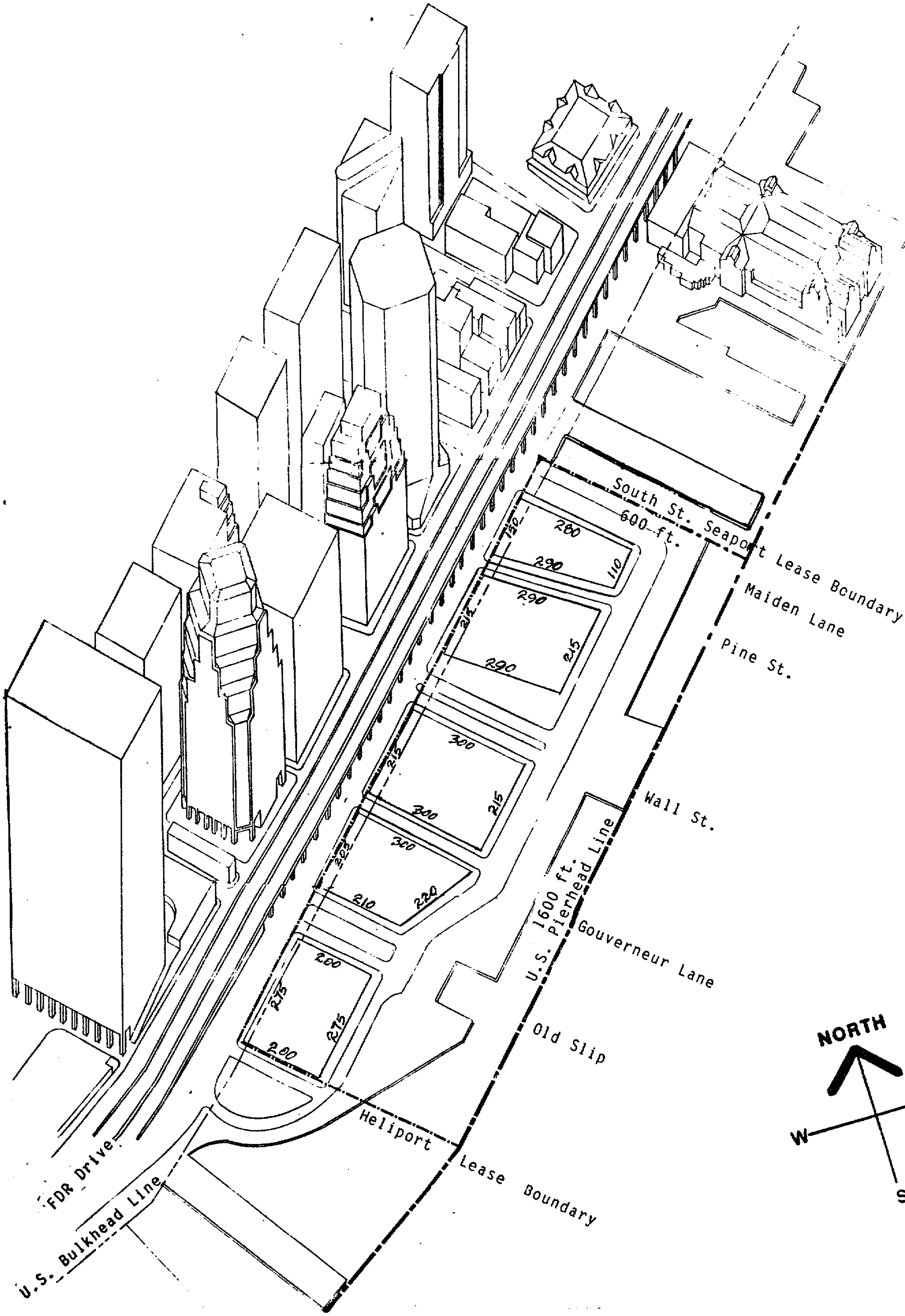
East River Landing has many unique features. It will replace now defunct piers and wharves that were productive in the age of clipper ships. The area was once one of the major resources that made New York a great port city. East River Landing is adjacent to the financial district with all of its high-rises and dark, congested streets. Five streets will cross underneath the FDR Drive, creating five blocks on the East River Landing, which will have a southeast to northwest axis. View corridors will be maintained on existing streets. The construction of East River Landing will once again unify the downtown area with the waterfront while providing open space, sunlight to the new buildings and streets, and allowing for scenic vistas of the harbor.

CONSTRAINTS AND GUIDELINES

The Special Manhattan Landing Development District was established to strengthen the business core, incorporate housing in Lower Manhattan, take advantage of the amenities of the East River waterfront and improve pedestrian circulation. Specific standards apply to each parcel in the district which generally can be described as a high-density mixed use area. The Department of City Planning is re-evaluating the special district and may suggest amendments in the future.



Map 6. STUDY AREA, EAST RIVER LANDING.



Map 7. EAST RIVER LANDING, PROPERTY LINES & DIMENSIONS.

The Department of City Planning guidelines for urban design in this area include:

1. Provisions for waterfront esplanade and other public open spaces.
2. Retention of view corridors.
3. Extension of street walls.
4. Integration of the new development with an expansion of the existing street grid of Lower Manhattan.
5. Provision of areas for ferry terminals.

EVALUATION OF SITING CRITERIA

Topography

East River Landing will be built on a flat, pile-supported deck structure over the water. Thus, the topography is suitable for solar access.

Southern Exposure

The waterfront site has an unobstructed southern exposure. Commerical high-rises to the west of the site limit southwestern exposure after 3:00 PM during the winter and after 4:00 PM during the summer. The proposed dimensions of on-site building bulks will partially shade each other in the afternoon hours after 2:00 PM during the winter and late afternoon during the summer months.

Solar Window

Sunchart photos showed there were no obstructions blocking the sun from the east, southeast and south. There are numerous commercial office towers to the southwest and west that will substantially block the sun after 3:00 PM in winter and 4:00 PM in summer (See Figures I3 and I4.).

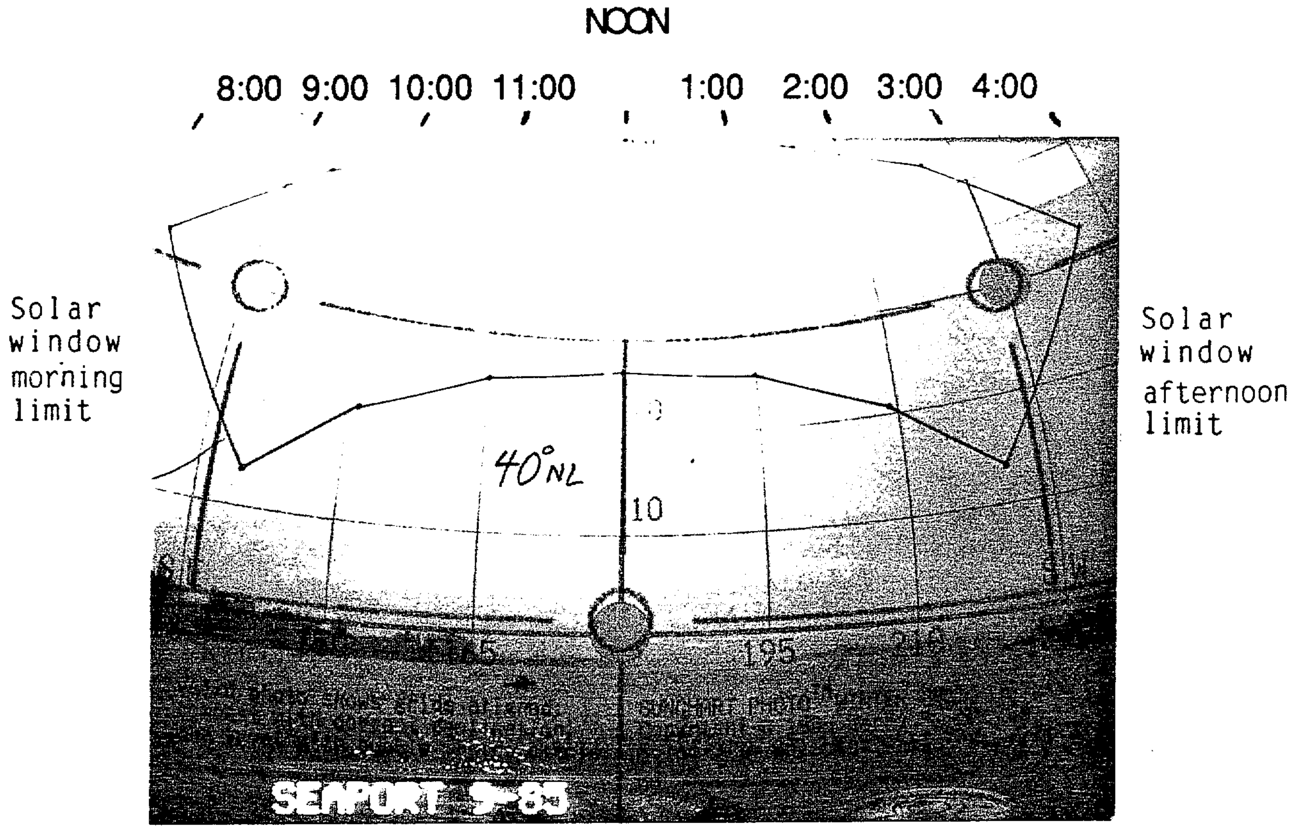


Fig. 13. SOLAR WINDOW, East River Landing site sunchart photo.
(Southwest corner of site looking east)

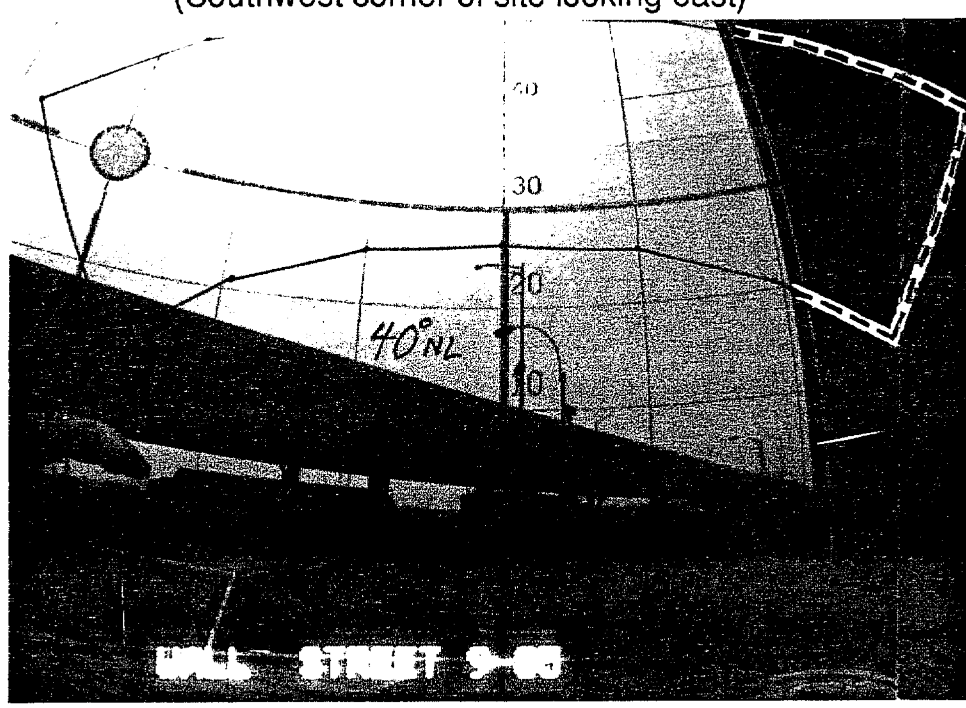


Fig. 14. SOLAR WINDOW, East River Landing site sunchart photo.
(2:00 PM blockage of sunlight in northernmost part of site)

Shading

Shading of East River Landing will occur primarily after 2:00 PM during the winter and 4:00 PM during the summer by commercial office towers to the west of the site. (The northernmost part of the site will be partially shaded at 2:00 PM, and other parts of the site will be shaded later.) Proposed buildings on the site will cast shadows on adjacent buildings in the mid-afternoon during the winter and late afternoon during the summer.

Street Configuration

The East River Landing street configuration was designed prior to the study. However, the proposed street pattern will not unduly hinder solar access protection because there are sufficient northwest-southeast streets crossing through the site to provide adequate sunlight.

Parcel Size

Design criteria determined parcel size. Two alternatives are provided; Plan 1, one parcel per block (Map 8); and Plan 2, two parcels per block (Map 9). Both alternatives, though not designed under solar access siting criteria, will not hinder the feasibility of solar access. However, with two parcels per block, the building bulk envelope for each parcel will be different in height and shape than the building bulk envelope for one parcel per block.

Building Orientation

Buildings are oriented in an east-west direction as much as possible so most walls and windows face south to take advantage of available sunlight provided by solar access zoning. Windows and walls facing northeast and northwest will not receive direct sunlight.

Bulk

Bulk conforms to proposed East River Landing guidelines. The building bulk is derived from construction of solar envelopes, specifically "modified solar envelopes," which, due to overall constraints of the site, allow some shading of neighboring properties. This bulk recommended for each parcel in Plan 1 and Plan 2 is suitable for solar access goals at this particular site.

APPLICATION

High-rises cast considerable shadows, particularly in the morning and afternoon hours, which either must be accommodated by l) decreasing the extent of solar access protection from south walls to rooftop levels; or 2) restricting the hours of sunlight to 9:00 AM to 3:00 PM, or to 10:00 AM to 2:00 PM at the minimum. Sunlight is best suited for daylighting of interior spaces. To apply the site criteria, a modified solar envelope has been created to delineate possible building volume and space for development under each alternative. The envelopes are designed to 1) prevent excessive shading of adjacent parts of the development during the sunlight hours specified; and 2) maximize building surfaces exposed to sunlight. The solar envelope has been adapted to use the unobstructed sunlight over the East River to the site. The envelope does not protect sunlight after 3:00 PM because of existing buildings to the west of the site. Thus, no provisions are made in the proposed envelope to preserve solar access after 3:00 PM. The bottom seventy (70) ft., equivalent to approximately six floors, of the high-rises in East River Landing will be shaded during the winter months. The South Street Seaport and other public spaces will not receive any shade from the proposed development until well after 2:00 PM. The solar envelope maximum buildable floor area is 7.5 million square feet of floor space.

Summary of findings for East River Landing

The following two site plans provide the street wall heights determined by construction of solar envelopes for 1) each block as one building bulk (Figure l5); and 2) each block as two building bulks (Figure 16). The building bulk could be further carved to produce more than one or two buildings within each envelope. However, the maximum building bulk is shown by means of the southeast, northeast, northwest and southwest corners, or solar poles at each of the corners (See Table 2 a, Table 2 b and Table 3.). The height of each corner is provided, along with other dimensions on site. In addition to the maximum height recommended at each corner, the present setbacks provided by underlying zoning for land parcels are recommended.

Below is a list of options available should implementation become appropriate in the East River Landing area of the Manhattan Landing District. They are as follows:

1) Incorporate guidelines for solar access as part of the New York City Department of General Services, Division of Real Property requirements from the New York City Private Development Corporation when East River Landing is made available for development.

2) Add text changes to the Zoning Resolution to provide for parcel-by-parcel heights and setbacks within a revised Special District.

3) Add text changes to the Zoning Resolution to incorporate parcel-by-parcel special permits.

Table 2 a. PLAN 1. PROPOSED HEIGHT RESTRICTIONS AT EACH CORNER OF EACH BLOCK.

Location	Block 1	Block 2	Block 3	Block 4	Block 5
	Height in feet				
Southwest corner	160	180	170	190	155
Southeast corner	250	180	250	190	290
Northwest corner	130	100	130	90	155
Northeast corner	130	100	150	90	290

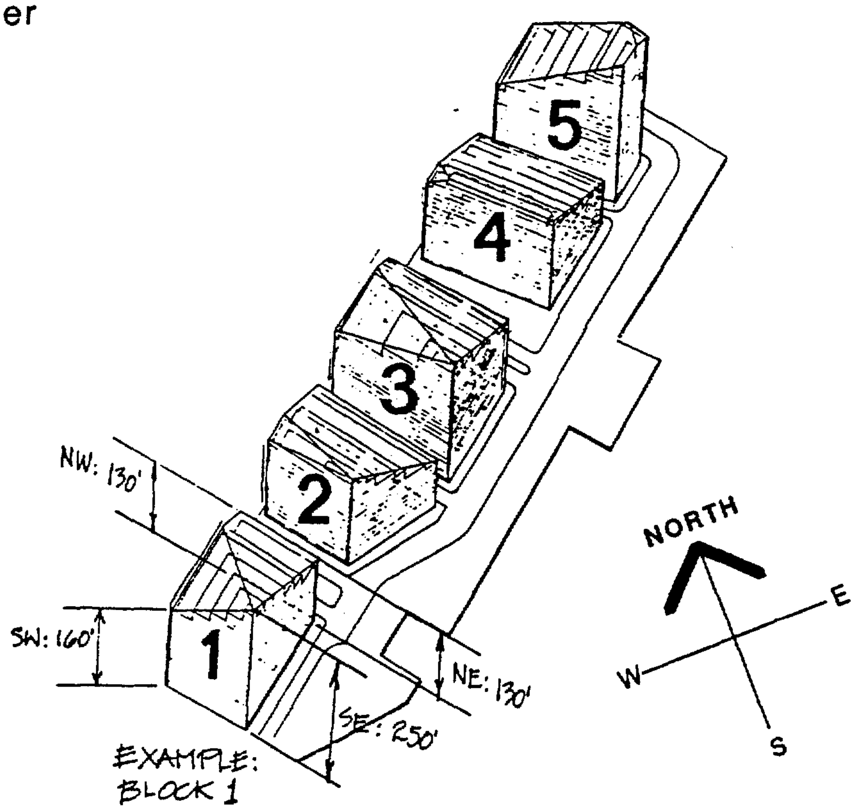
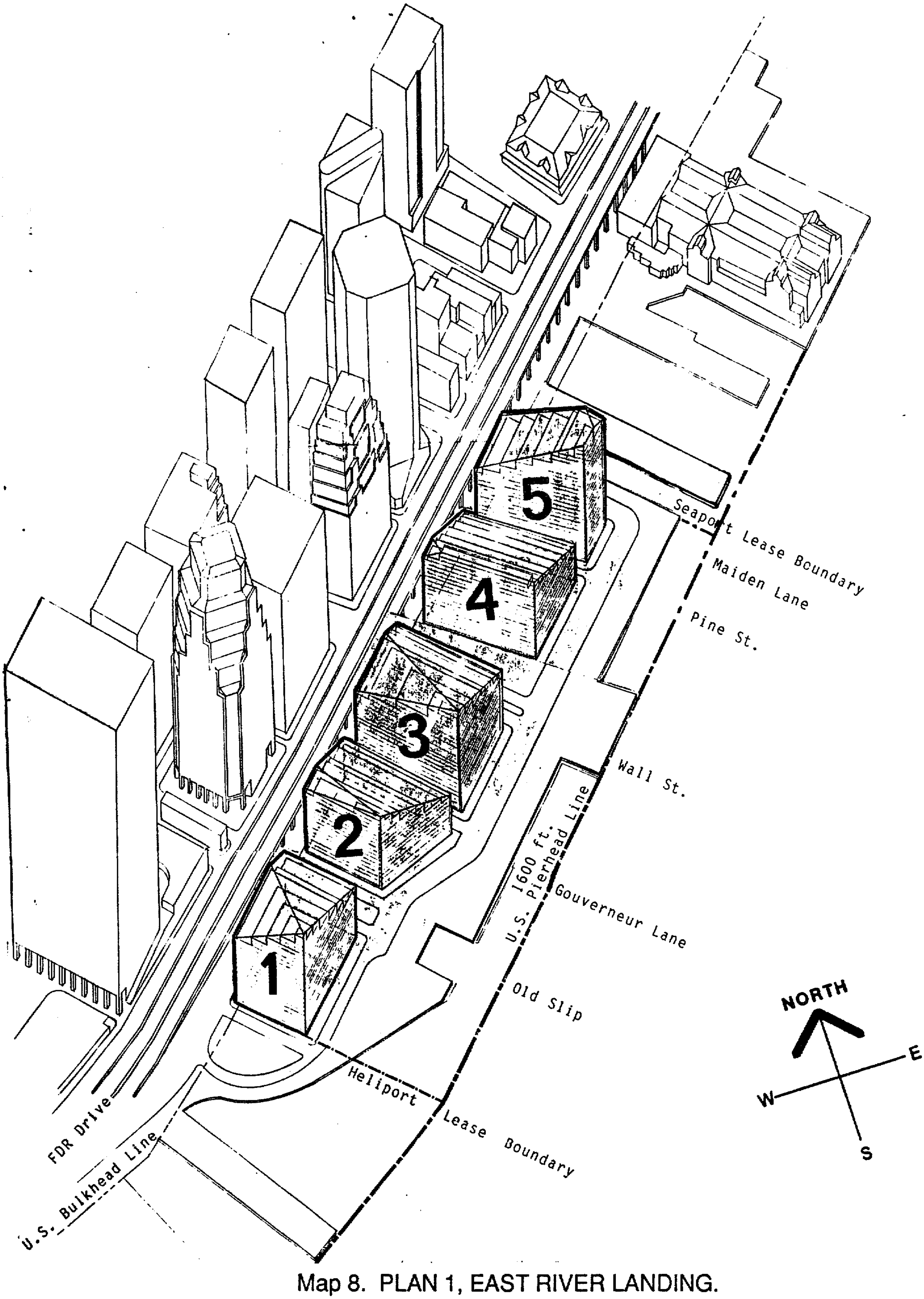


Fig. 15. Each block as one building bulk.



Map 8. PLAN 1, EAST RIVER LANDING.

For Plan 1, heights at each corner of block parcels are provided in Tables 2b and 3. In Table 2b, as-of-right zoning allows larger buildings which, in turn, cast excessive shadows on neighboring properties. By comparison, as shown in Table 2a for Plan 1, the solar envelope constraints are shown as maximum heights at each corner of a building which covers an entire block, and with 70 ft. of vertical shading of neighboring properties. When the modified solar envelope constraints are compared to Table 2b, as-of-right zoning for Plan 1, it is evident that current zoning allows larger buildings in all cases except on Block 5. However, under as-of-right zoning, there is shadow cast on the South Street Seaport from a building on Block 5. If remaining air-rights were obtained from the South Street Seaport, the building or buildings located on Block 5 could be much larger. Thus the shadow cast on the Seaport area would be greater.

Table 2b is based upon the following zoning:

Zoning District C5-3CR, with a commercial/office building Floor Area Ratio of 18, and a residential F.A.R. of 9, as per Z.R. Section 33-120.5;

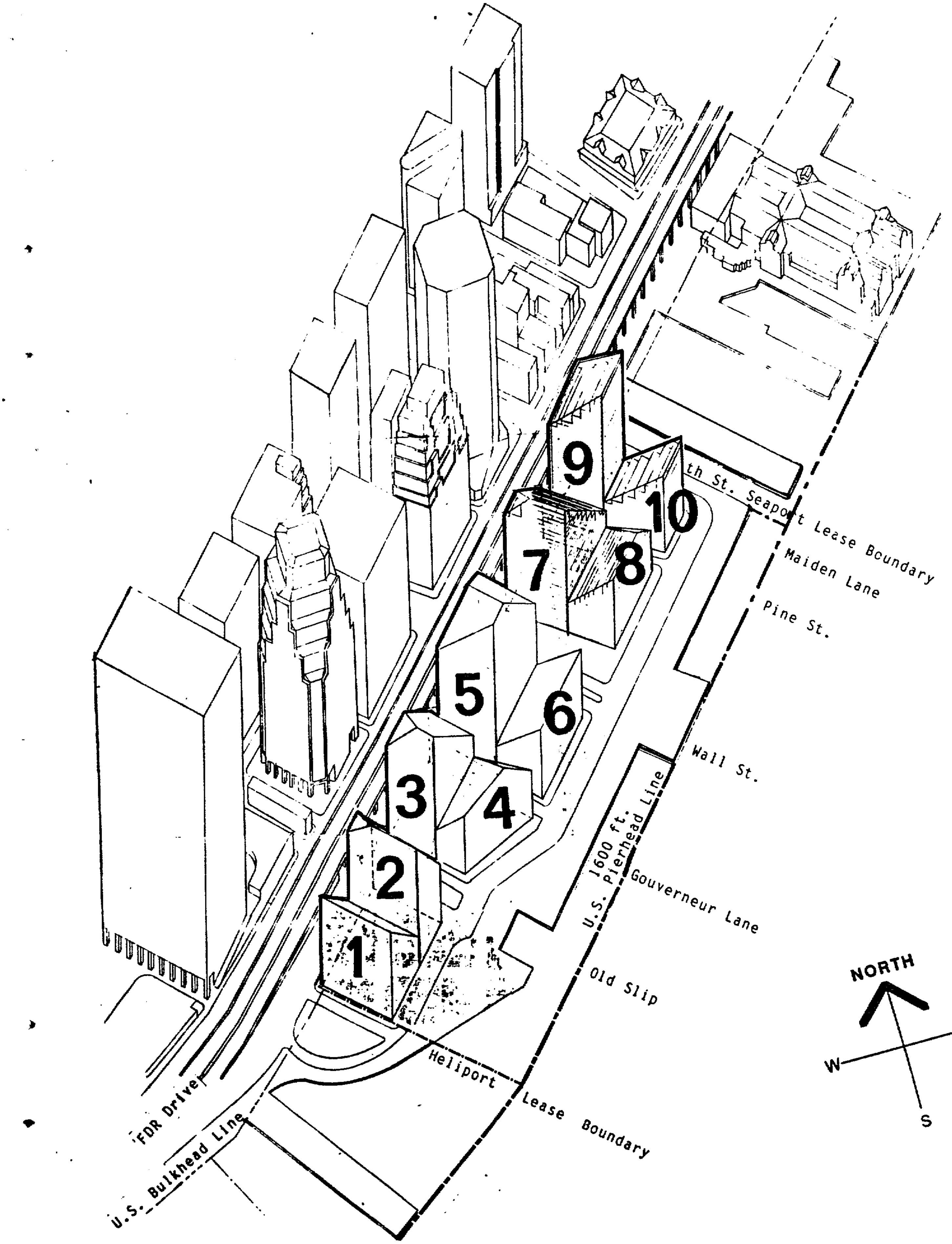
1) Sky exposure plane, as per Section 33-432,
initial horizontal setback from property line,
narrow street = 20 ft., and wide street = 15 ft.;
Street wall height = 85 ft. or six stories;
Sky exposure plane ratio, for narrow street = l.0 to 2.7 ft. of vertical rise to 1 ft. horizontal setback, and
for wide street = 5.6 ft. to l ft.

2) Alternative required front setbacks, as per Section 33-442,
initial horizontal setback from property line,
narrow street = l5 ft., and wide street = l0 ft.;
Street wall height = 85 ft. or six stories;
Sky exposure plane ratio, for narrow street = 3.7 to l ft., and
for wide street = 7.6 to l ft.

Note: For development under "tower" zoning, there would be no height restriction if a building occupies only forty (40) per cent of its site.

Table 2 b. PLAN 1. COMPARISON OF PROPOSED HEIGHT RESTRICTIONS AT A GIVEN SETBACK FROM CORNERS OF EACH BLOCK UNDER AS-OF-RIGHT ZONING (F.A.R. 18).

	Block 1	Block 2	Block 3	Block 4	Block 5
Location			Area in square feet		
Block size:	55,000	33,825	64,500	62,350	37,700
Floor area:	990,000	608,850	1161000	1122300	678,600
Southwest corner, setback & sloped setback:	I0 &7.6/I	10 &7.6/1	15 &3.7/1	I0&7.6/I	I5&3.7/I
			Distance in feet		
Allowable height:	300	206	403	404	261
Southeast corner, setback & sloped setback:	10&7.6/1	10&7.6/1	15&3.7/1	10&7.6/1	15&3.7/1
Height:	300	206	403	404	261
Northwest corner, setback & sloped setback:	10&7.6/1	15&3.7/1	10&7.6/1	15&3.7/1	10&7.6/1
Height:	300	211	393	395	256
Northeast corner, setback & sloped setback:	10&7.6/1	15&3.7/1	10&7.6/1	15&3,7/1	10&7.6/1
Height:	300	211	393	395	256



Map 9. PLAN 2, EAST RIVER LANDING.

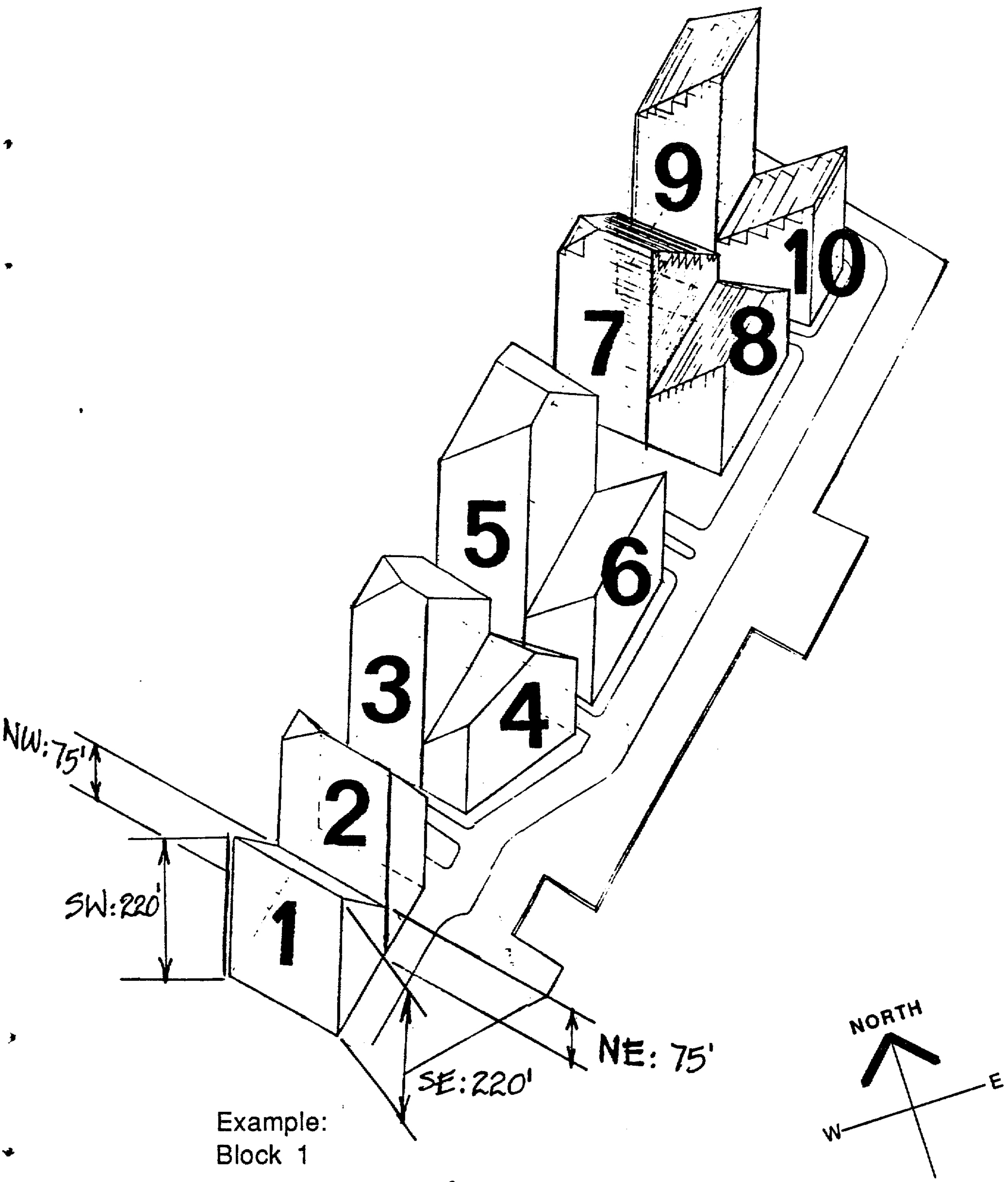


Fig. 16. Each block as two building bulks.

Table 3. PLAN 2. PROPOSED HEIGHT RESTRICTIONS AT EACH CORNER OF EACH BLOCK.

Location	Block 1	Block 2	Block 3	Block 4	Block 5
	Height in feet				
Southwest corner	220	280	225	75	225
Southeast corner	220	280	300	140	420
Northwest corner	75	145	125	75	225
Northeast corner	75	145	125	140	225

	Block 6	Block 7	Block 8	Block 9	Block 10
Southwest corner	75	300	110	240	75
Southeast corner	170	300	75	340	190
Northwest corner	75	120	75	240	75
Northeast corner	170	120	110	340	190

Note: No portion of a building should pierce any of the sloping "rooftop" planes which are constructed by connecting the heights at each corner of block parcels.

As-of-right zoning

The East River Landing site is currently a part of the Special Manhattan Landing Development District, a Special Purpose District under Section 98 of the Zoning Resolution. The Floor Area Ratio (F.A.R.), the ratio between lot area and allowable floor area that can be built on a lot, is a maximum of 18.0 for C5-3CR, the predominant zoning designation for the East River Landing site. The residential F.A.R. is limited to 9.0. Sky exposure planes are determined by provisions under Section 33-432 of the Zoning Resolution, with "Alternate Required Front Setbacks" provided under Section 33-442.

In Z.R. Section 98-171, a provision exists for sunlight to reach pedestrian space, but the pedestrian space which is shadowed by adjacent buildings such as those along Marginal Street or the future East River Landing are excluded.

Under Special Purpose District zoning, air-rights may be transferred from a low-density site such as the South Street Seaport to an adjacent site. However, the new building at the adjacent site cannot exceed an F.A.R. of 21.6.

At present there are no Special Purpose District zoning provisions which will help protect solar access at the South Street Seaport located to the north and northeast of East River Landing. The air-rights above the Seaport can be purchased for transfer to adjacent properties. Although this maintains the Seaport's scale, character and height of buildings within its site, neighboring buildings would grow much larger, robbing the Seaport's sunlight.

Benefits of conventional zoning

As-of-right zoning permits an F.A.R. of 18 which would allow more square footage of floor area in a building as compared to a building constrained by the solar envelope, or specifically the modified solar envelope (See Appendix 2.). With alternate setbacks and bonuses obtained by the developer of an East River Landing building, an additional F.A.R. of 3.6 is possible. Approximately twenty (20) per cent of additional square footage of floor area would be allowed, resulting in six to eight additional stories. As shown in Table 2b, the square footage of floor area under conventional zoning would be increased by approximately twenty (20) per cent for each block.

Benefits of solar access

Although less floor area would result, the benefit of natural lighting would be the main advantage of solar access. As will be discussed in Section 4 following, the economic payback is long for passive solar strategies, but the energy savings and quality of life in the workplace or in residences are nonetheless substantial.

The public benefit of solar access to the South Street Seaport is difficult to estimate in strictly economic terms, but the impact upon the Seaport due to excessive shading by future buildings built under conventional zoning can be lessened. Solar access would guarantee ample sunlight to an important historic place and open space benefits to the public at large.

Solar zoning would protect adjacent properties as well. Neighbors would receive much less shadow under solar zoning than under conventional zoning. This is evident when the modified solar envelope methodology is applied to each block. The solar envelope is modified because it is determined by the existing surroundings and site conditions, and it is increased uniformly in height which limits the shadow cast on neighboring buildings to be only seventy (70) feet on March 21 and September 21. To the west and northwest of East River Landing the adjacent properties have buildings whose loading platforms and service functions occur on the lower floors facing the East River Drive and the East River Landing site. The seventy ft. vertical shadow cast on these lower floors under solar access would be far less than the shadow cast by larger buildings built under conventional zoning.

SECTION 4

ECONOMIC IMPACT OF PROVIDING SOLAR ACCESS

This section evaluates the economic benefits of using solar energy in New York City. The economic analysis is broken down by categories: low-rise residential passive solar, low-rise residential passive solar, high-rise commercial passive solar, and photovoltaic solar energy.

Passive solar space heating is the most efficient method of harnassing the sun's energy. Passive systems such as greenhouses or sunspaces (See Section 1.) are cost effective for heating low- or high-rise residential buildings, when used with energy conservation techniques. For high-rise buildings, apartments which face south can make effective use of greenhouses or sunspaces, unlike those apartments which face north.

Low-rise Residential Passive Solar

Brookhaven National Laboratories and the U.S. Department of Energy (DOE) monitored a specially designed and constructed solar house. The house is a two-story, 1500 sq. ft. home, situated in a climate similar to that of New York City. By using energy conservation measures and passive solar energy, the house consumed less than one-third of the energy normally required to heat a conventional house (See Table 4.).

Table 4. ENERGY CONSERVATION COMPARISON OF CONVENTIONAL HOUSE TO BROOKHAVEN HOUSE.

Annual consumption	Conventional house	Brookhaven house
Heating oil	675 gallons	175 gallons
Electricity	(Data not available)	(Data not available)
Payback period	3 to 4 years	8 to 10 years
Total energy savings		70 per cent

Note: The Brookhaven House is continually monitored, and savings are slightly different each year. The savings given above occurred in 1982-83. Recent savings appear to be even greater.

Economic projections in this study are based upon the "simple payback" method in which the capital cost is divided by the annual savings to find the number of years necessary to pay back the capital cost. Other methods include "present worth" and "discounted rate of return." However, in projections for three to four years ahead, simple payback is as accurate as the other methods. Furthermore, these energy measures would not be implemented unless they have the shorter paybacks (i.e. 3 to 4 years); the simple payback method is appropriate. The other methods are dependent upon forecasting of inflation and fuel costs, and since prior studies based on these methods have often not been validated, they may be less predictable.

To assess the contribution of passive solar, a conventional residential unit without passive solar must be compared to a residential unit which is first retrofitted for energy conservation and then for passive solar, as follows in Table 5:

Table 5. ANNUAL COMPARISON OF COSTS AND SAVINGS.

Conventional house, annual consumption data	COSTS: Energy conservation applied to annual data	COSTS: Passive solar retro-fitted & applied to annual data	SAVINGS: Energy conservation	SAVINGS: Passive solar	SAVINGS: Passive solar with energy conservation *
Space heating (gas): $ 1200	$ 720	$ 600	$ 480	$ 120	$ 600
Domestic hot water: 240	120	120	120	---	120
Lights & appliances: 500	400	370	100	30	130
Air conditioning: 150	75	75	75	---	75
TOTALS	$ 2090	$ 1315	$ 1165	$ 775	$ 925

* Note: A passive solar house, as widely defined in design and in contemporary construction, has energy conservation measures, such as ample insulation along with its passive solar features.

Analysis:

Savings from energy conservation:	$ 775
Savings from passive solar:	150
Estimated capital costs, energy conservation	7000
Estimated capital costs, passive solar:	3000.
	$10,000

Analysis,
continued: Energy conservation payback: $\frac{\$\,7000}{775}$ = 9 years

Passive solar payback: $\frac{\$\,3000}{150}$ = 20 years

Payback with energy conservation
and passive solar combined
(simple payback): $\frac{\$10{,}000}{925}$ = 10 years

Insulation, whether installed by itself or provided in combination with passive solar features in a building, must be used in accordance with the local climate of New York City. Too much insulation entails a long payback period. The following summary of the actual role insulation plays supports the findings from Table 5:

Table 6. DIMINISHING RETURN OF INSULATION.

Amount of insulation by thickness in inches:	Annual BTU savings per sq. ft. of insulation	Increased cost per sq. ft.	Annual dollars savings per sq.ft.	Years for simple payback
3 1/2 to 6	3120	$ .16	$ 3.14	5.2
6 to 9 1/2	180	.22	1.84	12.2
9 1/2 to 12	720	.16	.70	22.8

The annual space heating cost savings were based on increased insulation in the walls and roof, reduced air infiltration due to tighter windows and doors, proper orientation of house to maximize passive solar energy, correct window size and thermal mass to absorb daytime solar heat gain for nighttime heating. Annual electrical costs were reduced by installing energy-efficient appliances such as refrigerator, air conditioner and laundry equipment, and by utilizing energy-efficient lamps. Domestic hot water costs were reduced by installing low-flow sink faucets, insulating jackets on the domestic hot water storage tank, using low-flow shower heads, and lowering the water temperature.

<u>Low-rise Residential Active Solar</u>
(Solar Domestic Hot Water Heating)

Based upon the survey data (See Appendix 1.), solar domestic hot water heating was not cost effective. Tax credits from the federal government and the State of New York covered 40 and 15 per cent, respectively, of the installation costs. The solar domestic hot water installation showed a simple payback of more than twenty (20) years, approaching the life of the solar equipment estimated at twenty-four (24) years. Simple payback was based upon present day fuel costs. If energy costs escalate in the future, then the payback will be shorter; if energy costs decline, the payback will be longer.

<u>Brooklyn Union Solar House case study</u>

The evaluation of the Brooklyn Union Gas solar house confirms that the solar domestic hot water heating is not economically viable at present. The Brooklyn Union Gas solar house case study is summarized in Table 7. Data from this study indicates that solar energy systems for domestic hot water heating results in an average savings of forty-seven (47) per cent of approximately $ 145.00 per year. The financial cost of the installation was $ 5000. The simple payback was thirty-two (32) years, which exceeds the expected life of the solar equipment (24 years). Maintenance costs range from $ 25 to $ 50 per year, thus lengthening the payback period.

Active Solar Space Heating

Based on the analysis of solar domestic hot water heating, active solar space heating would be even less cost effective since the collector cannot be used effectively year-round. Domestic hot water systems do provide substantial percentages of -- if not all -- hot water needs in summer months and do operate in winter, while active solar space heating is unnecessary in summer and has been found to contribute a small percentage of what is needed in winter.

Table 7. MONITORED RESULTS, THE BROOKLYN UNION GAS SOLAR HOUSE'S HOT WATER HEATING.

Solar energy system monitored by Brooklyn Union Gas, Brooklyn,NY

Site location: 62 Jacques Avenue, Staten Island, NY

<u>Solar collector system data</u>

Manufacturer: Ametek
No. of panels: Four (4)
Size of panel: 30 sq. ft. (estimated)
Storage tank: 120 gallons
Number of persons living in solar house: 3 or 4

Month and year		Gallons used	Total energy used in BTUs	Energy provided by solar in BTUs	Per cent solar
March 1983		1945	1593000	826000	48
April 1983		2162	1330000	492000	63
May 1983		2330	1275000	389000	69
June 1983		1544	823000	67000	91
July 1983		1448	790000	28000	96
August 1983		1775	858000	47000	94
September 1983		2101	927000	67000	92
October 1983	*high	2370	1149000	463000	59
November 1983		1568	1132000	640000	43
December 1983		1569	1449000	1055000	27
January 1984	*low	1180	1328000	1094000	17
February 1984		1302	1416000	1100000	22
March 1984		1551	1569000	1100000	29
April 1984		2017	1497000	800000	46
May 1984		2062	1130000	500000	55
June 1984		1770	940000	150000	84
July 1984		1760	970000	250000	74
August 1984		1585	766000	100000	86
September 1984		2030	910000	150000	83
October 1984		1998	1000000	500000	50
November 1984		1942	1069000	650000	39
December 1984		1675	1217000	920000	24
January 1985		1410	1375000	1100000	20
February 1985		1518	1382000	950000	31
March 1985		1719	1453000	800000	44
April 1985		1807	1133000	500000	55
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Totals		46,138	30,481,000	14,738,000	47 %

High-rise Residential Passive Solar

The ability of high-rise apartment buildings to benefit from passive solar access is limited by their access to solar energy. If a building's south-facing apartments have terraces, the terraces can be enclosed in glass to form a sunspace/greenhouse which can produce heat in the winter. North-facing apartments are limited in the amount of extra heat derived from the sun, and the extra heat which may be obtained in south-facing apartments is not easily distributed to north-facing apartments. High-density residential active solar faces the same problems as low-density residential active solar.

The cost of a sunspace/greenhouse may vary considerably, but it is estimated as approximately $14,500 for a 17 ft. x 6 ft. glass enclosure. The savings obtained may range from $ 500 to $ 1200, and assuming an average savings of $ 850, the simple payback is as follows:

$$\text{Cost of sunspace glass:} \quad \frac{\$\ 14{,}500}{\$\ 850} = 17 \text{ years}$$

High-rise Commercial Passive Solar

The main energy demand of commercial high-rises is for light and air-conditioning. Passive solar design can be used to minimize the amount of artificial light required by offices.

High-density commercial active solar faces the same problems as does residential active solar. Low-rise commercial does not exist as a land use in the two selected sites; thus, low-density commercial passive solar energy was not studied.

The lighting load for a typical office building is five kilowatts per sq. ft. per year or more. Studies by l) the Ehrenkrantz Group for the New York State Energy Office, and 2) the Tishman Realty and Construction Company show electrical consumption savings from solar "daylighting" and energy efficient lighting. (For comparable studies, the General Proceedings of the annual International Daylighting Conference provide additional information.)

The Ehrenkrantz Group measured the lighting load available from highly efficient lighting equipment, which provides 85 footcandles of light, and found the energy consumption to range from 2.4 to 2.5 watts per sq. ft. Tishman's evaluation of a new office building, Park Plaza in Newark, indicated that lighting represented about 25 per cent of the total energy consumption and about 45 per cent of the total when computers and computer-related loads were subtracted. Automatic controls that turn lights on and off by responding to occupancy of each space, provide 50 per cent and more savings in lighting energy consumption. Thus the lighting load can be reduced, ranging from 2.5 to 3 watts per sq. ft., by conserving energy.

The Ehrenkrantz Group further projected that passive solar utilization through daylighting would produce approximately 50 per cent savings beyond those savings accrued from energy conservation. The reduced load due to solar contribution to lighting is l to l.5 watts per sq. ft. whenever the space is being lighted (1800 to 2000 hours per year), at least within an area comprising 15 to 20 feet in depth around the periphery of an office building.

Skidmore Owings and Merrill designed the Irving Trust Bank building for the bank's computer facilities to achieve a similar load due to daylighting. Without task lighting (lighting which directly affects a person's immediate desk work area) and with a completely sufficient light level of 55 footcandles evenly distributed throughout the space, plus the contribution of daylighting, the load is 1.3 watts per sq. ft. (Comparable loads sought under conventional design of energy conserving office buildings range from 2.5 to 2 watts per sq. ft.)

Table 8 demonstrates the economic benefit of reducing energy consumption due to artificial lighting and the relative impact of daylighting. The tabulation is based upon the assumption that a new energy efficient building with daylighting will omit the daytime use of artificial lighting at the periphery of each floor, which constitutes approximately twenty (20) per cent of the total floor area. The connected light load of the non-peripheral interior would likely be reduced from 3 watts per sq. ft. to 1 watt. At the perimeter, the reduction would be even greater. The result would be approximately 0.4 watt per sq. ft. for an entire floor multiplied by 2000 hours of use per year equals 800 watts or 0.8 kilowatt.

Table 8. COMPARISON OF SAVINGS BETWEEN CONVENTIONAL OFFICE BUILDING AND DAYLIGHTED OFFICE BUILDING.

Annual consumption	Conventional office building	New office building with daylighting from passive solar
Electrical energy for artificial lighting	1.0 to 3 kilowatts/ sq. ft./year	.50 to 1.5 kilowatts/ sq. ft./year
Cost of electrical energy	$l.50/sq. ft. at perimeter	$l.50/sq. ft. at perimeter
Capital costs	Assuming $3.00 as an average cost for lighting installation at the perimeter of a floor	Assuming $6.00 at perimeter area, yet will be lighting twice as much area from sunlight

The savings and simple payback can be projected as best case and second best case, as follows:

Best case:

For daylighting strategies such as "light shelf" (bounces sunlight to the interior), etc., the most that can be saved would be \$l.50/sq. ft. at the perimeter and an additional \$l.50/sq. ft. for an adjacent interior area equal to the perimeter area.

\$ 6.00 for daylighted building
- 3.00 for conventional building
\$ 3.00 differential capital cost

divided by \$ 3.00 savings per year = l year payback

Next best case:

For daylighting strategies, assumed savings would be \$.75/sq. ft. at the perimeter and an additional \$.35/sq. ft. for an adjacent interior area equal to the perimeter area; equals a total of \$ l.l5 savings.;

\$ 3.00 differential capital cost

divided by \$ l.l5 savings per year = 3 years payback

To assess the impact of passive solar for high-density areas, a typical existing office building without state-of-the-art, energy-efficient features was compared to a new office building with energy-efficient features and daylighting but not passive solar heating.

The following considerations are taken into account in assessing the dollar value of the impact of energy conservation and passive solar in high-rises:

1. An energy-conserving building cannot be actually separated from a passive solar building. The energy conservation design of the building envelope (or skin), its orientation, its plan, its windows and other materials is inherent in a passive solar high-rise.

2. Energy conservation measures can be identified that are not closely related to passive solar; for example, more efficient lamps, boilers, air conditioning chillers, cooling towers, heat exchangers, daylighting timers to switch off artificial lighting when unneeded, and dimmers.

Economic impact is best projected by comparing the energy consumption measured in British Thermal Units (BTUs) per sq. ft. per year, as follows in Table 9:

Table 9. COMPARISON OF ENERGY CONSUMPTION.

Conventional office building	Office building with energy conservation (without daylighting)	Office building with passive solar (with daylighting and energy conservation)
160,000 BTU/sq. ft./yr.	55,000 to 78,000 BTUs/sq. ft./year	35,000 to 40,000 BTUs/sq. ft./year

Note: BTU is British Thermal Unit,the energy required to raise a pound of water one degree Fahrenheit in the temperature range between 62 and 63 degrees Fahrenheit.

The impact of photovoltaic systems

Photovoltaic solar systems convert sunlight to electricity. Consolidated Edison (Con-Ed) is currently monitoring the photovoltaic experiment at the Citicorps Building in New York City. The project was jointly funded by Empire State Electrical Energy Research Corporation (ESEERCO) and Con-Ed. The purpose of the research was to evaluate on-site performance of an installed photovoltaic system in New York City. Adjacent to the photovoltaic panels, a weather station measures the solar energy per square foot.

The facility has a gross collector area of six hundred sq. ft. Each I ft. x 4 ft. panel is composed of 35 single circular crystal cells. The net area of cells is 450 sq. ft. The cells are manufactured by Atlantic-Richfield (ARCO) and were installed in April, I983.

The photovoltaic cells have a system efficiency of ten (10) per cent; the estimated overall system efficiency is five to six per cent. The efficiency includes DC (direct current) to AC (alternating current) conversion. AC currents are supplied in offices and homes. This means that for every BTU of thermal energy from the sun, five to six per cent is converted to electricity at the point of use; in this case, at the office building.

The peak installed capacity at the office building site is five kilowatts (equal to 5000 watts) with a generating capacity of 4300 kilowatt hours per year. Although the facility is for experimental purposes and the capital costs much greater than a large-scale installation, the photovoltaic system cost ranged from $I4 to $20 per peak watt installed. (A peak watt is the maximum electrical energy produced on a sunny day at noon.) The calculations in Table 10 show over a century-long payback period, thus making photovoltaics unmarketable at this time. Technological advances in photovoltaics might lead to a more favorable economic payback in the future.

Table10. PHOTOVOLTAICS.

Generating capacity of 4000 to 4300 kilowatt hours, yielding five kilowatts or 5000 watts per year, multiplied by the cost per peak watt installed:

5000 watts x \$ 14 = \$ 70,000

5000 watts x \$ 20 = \$100,000

Value of electricity generated:

4000 kilowatt hours x \$.15/kilowatt = \$ 600 savings

4300 kilowatt hours x \$.15/kilowatt = \$ 645 savings

Cost divided by value of electricity:

$$\frac{\$\ 70{,}000}{\$\ 600} = 117 \text{ years} \qquad \frac{\$\ 100{,}000}{\$\ 645} = 155 \text{ years}$$

Conclusion

Based upon this study, passive solar energy is effective in low-rise residential and high-rise commercial buildings. For low-rise residential buildings, a single family home can save two-thirds to three-fourths of the energy normally consumed by using passive solar energy and energy conservation measures. High-rise commercial buildings can achieve substantial savings through the use of daylighting techniques.

Active solar energy and photovoltaics in all applications for New York City were found to be uneconomical. Passive solar energy has the shortest payback period and is the most viable alternative to fossil fuels.

SECTION 5

LEGAL EVALUATION FOR SOLAR ACCESS

This section evaluates the various legal methods that have been successfully implemented in other parts of the country, such as solar easement, solar covenant, and solar permits, to protect solar access. The focus will be on legal alternatives for solar access for New York City, such as normal height and setback controls, and solar zoning. The following questions were chosen to evaluate current legal possibilities for solar access protection:

1. How successful have solar easements and covenants been in implementing solar access?

2. Will solar envelopes be construed as an unconstitutional taking of property without due process under the U.S. Constitution?

3. How can zoning implement solar access?

Landowners have a legal right to sunlight falling perpendicularly on their land, for a man is said to own his property "from the center of the earth straight up to the heavens," (Prosser, Law of Torts, Sec. 13). However, landowners in the United States have no right to receive solar energy that would reach their land only after slanting across property owned by others.

Private sector approaches

Private sector approaches such as easements and covenants are allowed in a number of states. Owners of solar facilities may want a right to receive sunlight across adjacent land. The alternatives are outright purchase of adjacent property, purchase of airspace over the property, or purchase of an easement for light across the property. The first two solutions are expensive in most situations. An easement is a property right in land belonging to another, and the creation of an easement requires legal formalities. It cannot be revoked or terminated at will, although it may be limited to a specified time. In an affirmative easement, for example a right-of-way, the purchaser has a right to enter the land of the seller to the extent specified in the easement. In a negative easement the purchaser does not acquire the right to enter the seller's land, but the seller is restrained from doing something on the land that would be allowed if the easement did not exist. An easement for light is a prime example of a negative easement. The purchaser of the negative easement cannot enter the land restricted by the easement (restricted land) but can prevent the landowner who is restricted from interfering with the passage of light according to the easement forms. For example, the easement owner for light could seek a court order to remove obstructions that exceeded the height stated in the easement. Thus, the purchaser is assured of receiving lateral light to the solar facility. Negative easements, including easements for lights, must be negotiated among the parties. In urban areas, the easement cost would be high because it would limit vertical development that accounts for much of the land value. The costs and difficulties of negotiating satisfactory agreements between property owners could limit the appeal of easements.

The major advantage to solar easements is that they are usually permanent and consequently "run with the land." They also require minimal government involvement and are not affected by zoning changes on adjacent property.

Solar easement use is simple in theory yet complex in an urban setting. Even if the parties voluntarily agree to such restrictions, the restriction of developable airspace over several lots to the south of a solar facility may be prohibitively expensive. One could envision a complex set of restrictions where owners are not sure when a violation has occurred. Multiple restrictions would complicate title companies' ability to certify clear title as well as realtors' ability to determine the buildable area of a lot.

For new subdivisions, restrictive covenants may be more useful than solar easements. A covenant is an agreement among parties which acts as a deed restriction. Developers can insert covenants protecting solar access in deeds to new buyers, binding lot owners. In fact, some communities grant a density bonus for the filing of a restrictive covenant against shading from direct sunlight under their planned unit development (PUD) provisions; (for example, Lincoln, Nebraska, Design Standards for Zoning Regulations, adopted in 1979).

Covenants possess the same potential problems as easements because they both depend on numerous agreements to guarantee solar access.

The other alternatives to private agreements are zoning and governmental mechanisms to guarantee solar access. In the United States, Oregon and Maryland now authorize municipal laws protecting and assuring access to incident solar energy. Other states including Arizona, Michigan and Illinois are currently considering similar action. The State of New York amended the zoning enabling statute to provide that zoning regulations of cities, towns and villages may consider solar energy. The statute stipulates that municipal zoning regulations could be designed, in part, "to make provision for," so far as conditions may permit, the accommodation of solar energy systems, equipment and access to sunlight (General City Law, 20).

Solar zoning must not conflict with the federal constitution. The Fourteenth Amendment prohibits any state from depriving persons of property without due process and prohibits states from denying equal protection of the law. Use restrictions on real property must be reasonably necessary to achieve a substantial public purpose. When a property owner challenges a zoning ordinance, the court decides if the restrictions can reasonably be deemed to promote community purposes, and will include consideration of the treatment of similar parcels.

<u>Solar zoning</u>

Local governments that implemented solar zoning are Davis and Century City in California; Colorado Springs, Pilken and India County in Colorado; Albuquerque and Los Alamos in New Mexico; Largo, Forida; and most recently, Portland, Oregon. In solar zoning, municipalities define "solar zones" in which solar use is encouraged. Solar use may be compatible with a variety of neighborhoods, including commercial, industrial, or residential areas. Solar zones may be overlaid on existing zoning. Existing zoning categories such as general commercial or residential are not altered or replaced, but defined portions of appropriate zones are given an additional solar classification. Exemptions may be granted for individual lots, or for groups of lots which are planned together for an energy efficient layout.

All new construction in solar zones could be subjected to strict height and spacing controls to minimize shading of neighboring properties.

For several years, Los Alamos, New Mexico, has used a prior-appropriation by permit approach. The ordinance is a zoning amendment that protects solar collectors from shading by a hypothetical twelve-foot fence at the lot line between the hours of 10:00 AM to 3:00 PM, provided that the solar collector is not greater than one-half the floor area it serves. The ease of application of the permit makes it a viable tool for protecting solar access. A drawback is that the municipal permit required to vest rights under this strategy sounds like a rezoning. To be upheld against an opponent whose development options are restricted, the due process accorded a rezoning may be necessary, such as public hearings, notification, and registration.

Large developments

Special kinds of flexible municipal laws are used to control large developments that offer innovative approaches. One such law is bonus zoning where a landowner receives the right to incremental increase of property in exchange for providing a public amenity. This is often used to obtain public open spaces without cost to the city and could be adapted to procure solar use in the development or minimize shading to neighboring properties.

Cluster zoning could permit a developer to group buildings near the northern edge of the property and to aggregate the required open space to the south. Access to both direct and reflected sunlight would be protected to some degree by the southerly open space; the grouped buildings would require less heat by protecting each other from the elements.

Advantages of solar zoning

I. Zoning is an effective regulatory tool for land use planning. The addition of "solar zones" could be incorporated into existing zoning laws and would not add significantly to municipal burdens.

2. Potential solar users would know before deciding whether or not to install a solar device, whether their property was located in a "solar zone" and, if so, the nature and extent of the protection which they would receive.

3. In passing zoning laws, cities are in a good position to weigh the competing interests of both potential solar users and their neighbors and are likely to limit their restrictions to those which are reasonable for all parties. Such restrictions may mean, for example, that access is provided in some areas to permit only solar hot-water heating and not space heating, or that no protection would be provided in areas expected to develop densely.

4. Solar zoning does not permanently freeze land use, as cities retain the right to amend all laws in response to changes in local conditions.

5. Adequate enforcement of the solar right would generally occur when new development is planned, since building permits should not be issued for buildings which would contravene zoning laws.

Disadvantages of solar zoning

I. Solar zoning is not a secure protection of solar access, as laws may be changed at any time.

2. Zoning cannot be established or enforced by individuals but only by the city and, therefore, provides no protection for isolated solar pioneers.

3. Solar zoning can be only partially successful in existing areas, as structures cannot be moved to meet new requirements.

Conclusion

Solar zoning offers the best means of integrating solar rights with land-use planning. The cost of solar easements is likely to be high for airspace over urban property. The voluntary nature, along with the expenses and complexities, of restrictive covenants or solar easements offer no benefits over the solar envelope zoning in urban areas. Restrictive covenants seem most appropriate in large-scale developments through imposed deed restrictions on all buyers.

Private alternatives are attractive only when conceptually simplified and applied to low-density development. To protect solar access for a single lot, several lots to the south must be restricted by solar easements. Multiply this easement requirement by several lots, and the result is multi-layered restrictions over those lots. The restricted lot would have the same amount of buildable area allowed by the multiple easement restrictions that would be very similar in shape and volume as a solar envelope.

Solar zoning achieves the desired results of solar users without the expense, complexity and time consumption required for restrictive easements or deed covenants.

SOLAR ACCESS STUDY SUMMARY OF FINDINGS

Conclusion

Numerous local governmental bodies around the country are investigating the potential for solar energy to replace fossil fuels as an energy source. One of the prerequisites to achieve this goal is the protection of direct sunlight to solar facilities. The most effective and efficient way to preserve people's opportunity to receive sunlight is through Solar Access Control.

Siting criteria were developed to determine what areas are suitable for solar energy use and how these areas can be enhanced to take even more advantage of the sun's free energy. The siting criteria (See Section 2.) incorporated land-use, transportation, and building bulk elements to maximize the availability of sunlight to dwellings and buildings.

A methodology (See Section 2.) was developed to incorporate the siting criteria into a uniform application procedure called the Solar Envelope. The solar envelope was based upon geometric angles and dimensions to satisfy the siting criteria's qualifications.

Thus the two selected sites -- Annadale-Huguenot, Staten Island; and East River Landing, Manhattan -- were evaluated by the siting criteria and reconfigured by the solar envelope. The result was a workable development of homes and buildings that were achievable under Solar Access Control.

The investigation of solar energy economics was based upon the payback periods of the solar energy equipment. The payback period refers to the length of time investors of solar energy facilities would have to wait before receiving a full return on their investment in energy-saving equipment or building features. The payback periods comparing solar energy equipment to conventional energy systems for both a hypothetical homeowner and commercial developer were computed in Section 4.

In both test situations, the payback periods in all categories of solar use -- except for low-rise residential passive solar and for new high-rise passive solar daylighting -- were longer than those for conventional energy. Therefore, a hypothetical homeowner and commercial developer would find conventional energy sources more economical than solar energy and would be unlikely to invest in solar energy facilities.

Although, in general, solar energy is less economical than conventional energy sources, other considerations make solar energy use attractive. First, the building features of low-rise residential passive solar can be easily incorporated in the initial construction of homes, the additional cost largely consisting of additional materials such as extra masonry to provide thermal mass. Second, although active solar systems are not economical at the present, some solar heating for residential and commercial buildings may have payback periods sufficient for some property owners. Third, solar domestic hot water heating is an attractive investment when utility electric rates are high. Fourth, use of solar energy would reduce New York City's reliance on fossil fuels, which is particularly important in the face of changing world conditions and fluctuating oil prices. Furthermore, unlike conventional energy sources, solar energy does not contribute to air pollution. Finally, solar energy can lower the demand placed upon conventional utilities by energy consumers.

Solar Access Control is an effective and useful way of preserving property owners' access to direct sunlight. Current economic conditions, coupled with the relatively high cost of installing and operating solar energy equipment in comparison to other energy sources, produce an unfavorable investment condition for the average person living in New York City. A monitoring of economic conditions and the ongoing advancements in solar technology will enable the city, when the appropriate opportunity arises, to act -- thus encouraging the use of solar energy in New York City.

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APPENDIX 1

INVENTORY OF SOLAR FACILITIES IN NEW YORK CITY

Active solar energy uses in residential and business settings within New York City were investigated to determine the various ways solar energy is collected, stored and used. The goals of the inventory were to locate as many collectors as possible, to determine how many collectors actually were in use, to determine the number of businesses and residences that had working solar systems, and to compute the amount of money solar collector owners saved by investing in solar energy.

Persons connected to the solar field were solicited to obtain names of persons and businesses that use solar collectors. These sources revealed other locations of solar collectors and led to more information concerning other solar experts and businesses. In addition to the help the above-mentioned experts provided, old newspaper clippings, federal/ state and city government information sources, area academic institutions, and regional solar manufacturers were canvassed. Finally, a city-wide press release was issued that requested the public to report the locations of any solar collectors to the Department of City Planning.

The Department of City Planning, with the assistance of graduate students and solar experts, developed a questionnaire. This questionnaire was used to organize information obtained by telephone interviews with solar collector owners.

The next step was to contact the solar collector owners. The Department of City Planning mailed ninety-eight (98) informational packets to known solar owners which contained a letter describing the study and a multi-questioned, pre-stamped, and addressed response card. Owners were asked about the working condition of the solar system and requested to rate their system on the response card. Respondents were also asked to indicate whether they would like to have an interview to discuss their solar energy system.

The Department of City Planning encountered many problems in locating solar collectors. Solar manufacturers and small solar retailers within New York were either reluctant to provide addresses, were out of business, or were unavailable for comment. Only two firms were willing to retrieve files of past solar installations. Federal, state and city governments were very cooperative but did not have much substantive information related to the actual location of solar facilities.

This search into the location of active solar collectors revealed a number of findings. (Passive solar facilities were not sought.) In 1979, the cost of installing a solar system for the average house ranged from $3000 to $6000 after federal, state and city solar energy income tax credits. The income tax credits are no longer available; a solar system had to be operational by January 1, 1986, to qualify for federal and state income tax credits, but the New York State Real Property Tax Law, enacted in 1977 and amended in 1979, provides a fifteen (15) year real estate tax exemption for eligible solar and wind energy systems constructed prior to July 1, 1988.

The total number of respondents with current working solar systems were forty (40) out of the forty-two (42) reported solar systems. In addition, the inventory provided evidence that some individual owners have had their solar collectors shaded from direct sunlight by buildings and tall trees. They expressed an interest in whether New York City plans to help preserve their solar access.

Inventory results

Summary:

Mailed letters..........98

Returned letters to the agency...........42

Persons interested in further interview....38

Actual completed interviews...........20

Working solar units....40

Non-working units...... 2

Average age of the solar collector....4.63

Residential use........41

Business use........... 1

Performance rating of solar installations:

- Excellent............20
- Good.................16
- Fair.................. 0
- Poor.................. 5

Location of solar collection systems

Brooklyn:

33 Prospect Pl., 11217
201 6th Ave., 11217
554 1st St., 11215
2171 Cropsey Ave.,11214
1922-1 Troutman St.
227-6500 16th Ave.,11204
14 Pierrepont St., 11201
577 6th St., 11215
340 Marine Ave., 11209
108 1/2 Douglas St.,11231
370-372 Hooper St., 11211
128 State St., 11201
267 6th Ave., 11215
313 12th St., 11215
150 55th St.
638 Bushwick Ave., 11221
29 Fort Green, 11217
18 College Pl., 11201
1410 Bedford Ave., 11216
2370 E. 29th St., 11229
1433 E. 57th St.

Staten Island:

49 Mohn Pl., 10301
2400 Manhattan Bldg.
62 Jacques Ave., 10306
129 Fairfield St., 10308

Queens:

42 E. 221 1st St., 10013
25 E. 221 1st St., 11697
38 E. 221 1st St., 10013
151-14 Bayside Ave., 11354
117 E. 222nd St., 11697
159-39 89th St., 11414
1807 Heckaher Blvd., 11706
126-30 144th St.
121-17 198th St., 11413
80-30 164th St.
159-39 89th St.
29-11 Queens Plaza, 11101
216-32 Rockaway Point Blvd., 11209
36 E. 221st St., 10013
29-04 203rd St., 11360
217-62 Corbett Rd., 11361
2 E. 220th St., 11697
107 E. 222nd St., 11697
118-29 Queens Blvd., 11377
111-32 167th St.
27-32 Humphrey St.
8613 90th St.

Manhattan:

53 W. 94th St., 10025
320 W. 11th St., 10014
924 W.E.A., 10025
110 W. 81st St., 10024
28 Hubert St., 10014
225 E. 30th St., 10015
274 W. 11th St., 10011
381 Park Ave. So.,10010
421 Hudson St., 10014
777 10th Ave.
62,64 W. 89th St.
484 W. 12th St., 11215
114 Washington Pl., 10014
43 W. 94th St., 10025
423 W. 22nd St., 110011
315 W. 92nd St., 10025
42 W. 12th St., 10011
143 W. 95th St., 10025
19 W. 44th St.
33 E. 11th St.
523 E. 5th St.
319 W. 89th St.
50 W. 11th St., 10011
313 W. 89th St., 10024
16 W. 9th St., 10011
43 W. 48th St., 10036
331 W. 71st St., 10023
333 W. 88th St., 10024
129 E. 61st St., 10021
439 W. 22nd St., 10111
90 Beekman St.
90 St. at E. River, 10028
59,61 W. 88th St.
56 W. 89th St., 10024
331 W. 71st St., 10023
320 W. 15th St., 10011
25 W. 88th St., 10024
52 W. 76th St., 10023
44 W. 94th St., 10025
72 Bank St., 10014
32 W. 89th St.
519 E. 11th St.
353 W. 57th St.
948 Columbus Ave.
72 Bank St., 10014

APPENDIX 2

CONSTRUCTION OF SOLAR ENVELOPE (See Section 2.)

Construction of a solar envelope for a land parcel involves creating axonometric drawings. Axonometric drawings provide a point of reference similar to aerial photographs at an oblique angle. An axonometric diagram shows vertical and horizontal dimensions as they exist, to scale, in reality. To create an axonometric drawing, a drafting triangle is used to draw angles and lines. To draw the axonometric diagram for a solar envelope, the altitude and azimuth angles for New York City (provided in Table 11) must be used. The following procedure for drawing the axonometric diagram for a solar envelope first details the step-by-step method for a "modified solar envelope" and then shows the longer, more complicated method for constructing solar envelopes at the Annadale-Huguenot site:

Step 1 -- Locate the corners of the land parcel and mark them. Then mark the middle of the land parcel and place other marks equidistant from the middle mark to all the corners and place marks equidistant from each corner to each corner (See Fig. l7.).

Step 2 -- After completing Step 1, go back to each mark previously made and using Table 11, draw the azimuth angle from the mark outwards until the line strikes an adjacent property (neighboring property lines at ground level). Do not include streets, sidewalks and greenspaces as adjacent property.

Step 3 -- Duplicate this process eight more times on separate sheets of transparent paper using all the different azimuth angles provided in Table 11.

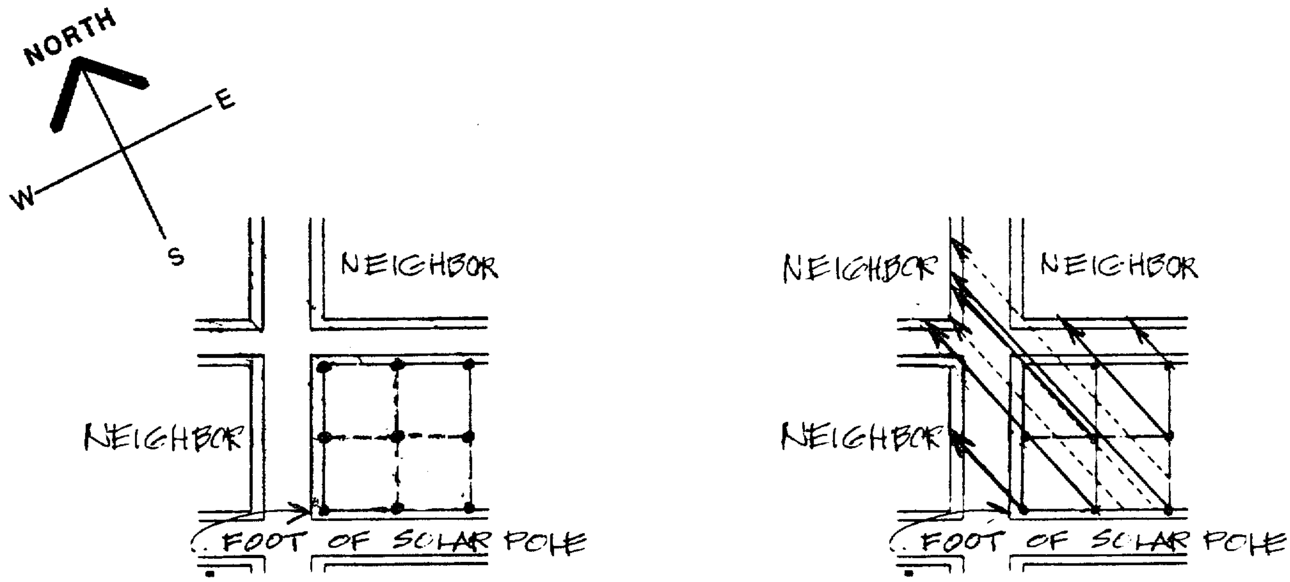
Step 4 -- Where the lines in Step 2 reach the first adjacent property determine the length of that line. Then multiply the distance by the tangent of the altitude angle supplied in Table 11. This will determine --for specific hours-- the maximum height of any building or tree at that particular point at the marks that were made in Step 1. Thus, a "solar pole" has been constructed on top of each mark that was made on the original land parcel. Duplicate this process eight more times for all the times provided in Table 11.

Step 5 -- Draw a line from the top of the solar pole to where the line in Step 1 hits the adjacent property. A cross-section of a solar plane has been constructed.

Step 6 -- Place all the transparencies of the solar planes on top of each other. At every location where the solar planes bisect, place a dot on the paper. After all the bisecting lines have been dotted, draw lines from the dots outwards to the corners of the property or to the nearest boundary, whichever is closest to the dot. A solar envelope, or specifically a "modified solar envelope" is constructed.

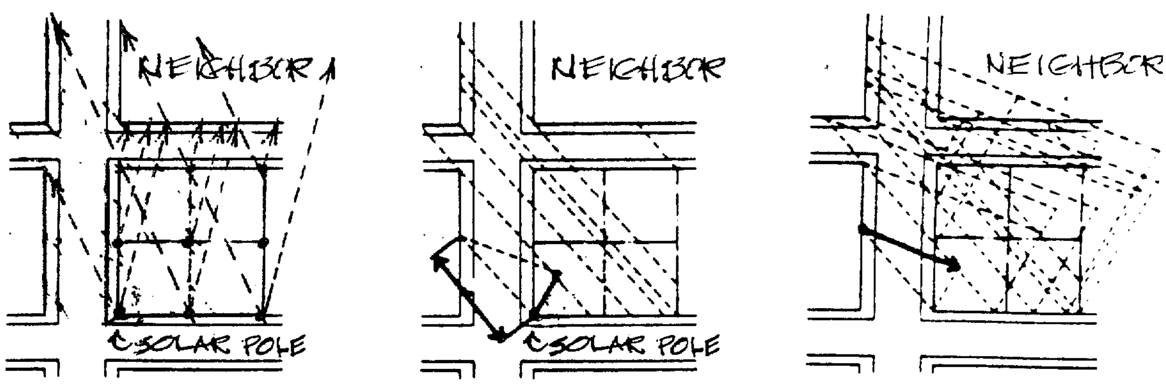
This procedure is illustrated as the modified solar envelopes prepared for the East River Landing site in Figure 18.

The longer procedure is next illustrated for the Annadale-Huguenot site, including the division of a solar envelope into smaller envelopes, in Figure 19.



Step 1
Marking where solar poles are

Step 2
Azimuth angles as lines drawn on the site



Step 3
Measuring each azimuth line

Step 4
Measuring each azimuth line & calculating the height of solar pole

Step 5
Drawing line from top of solar pole to where azimuth line hits adjacent property

Fig. 17. CONSTRUCTION OF SOLAR ENVELOPE.

Table 11. AZIMUTH AND ALTITUDE OF THE SUN.

Date	9:00 AM and 3:00 PM	10:00 AM and 2:00 PM	12:00 Noon
December 21			
Azimuth	138.1	150.6	180
Altitude	14.0	20.7	26.5
Tangent of altitude angle	0.249	0.378	0.498
March 21 & Sept. 21			
Azimuth	122.7	138.1	180
Altitude	32.8	41.6	50
Tangent of altitude angle	0.644	0.887	1.19
June 21			
Azimuth	99.8	114.2	180
Altitude	48.8	59.8	73.5
Tangent of altitude angle	1.142	1.718	3.376

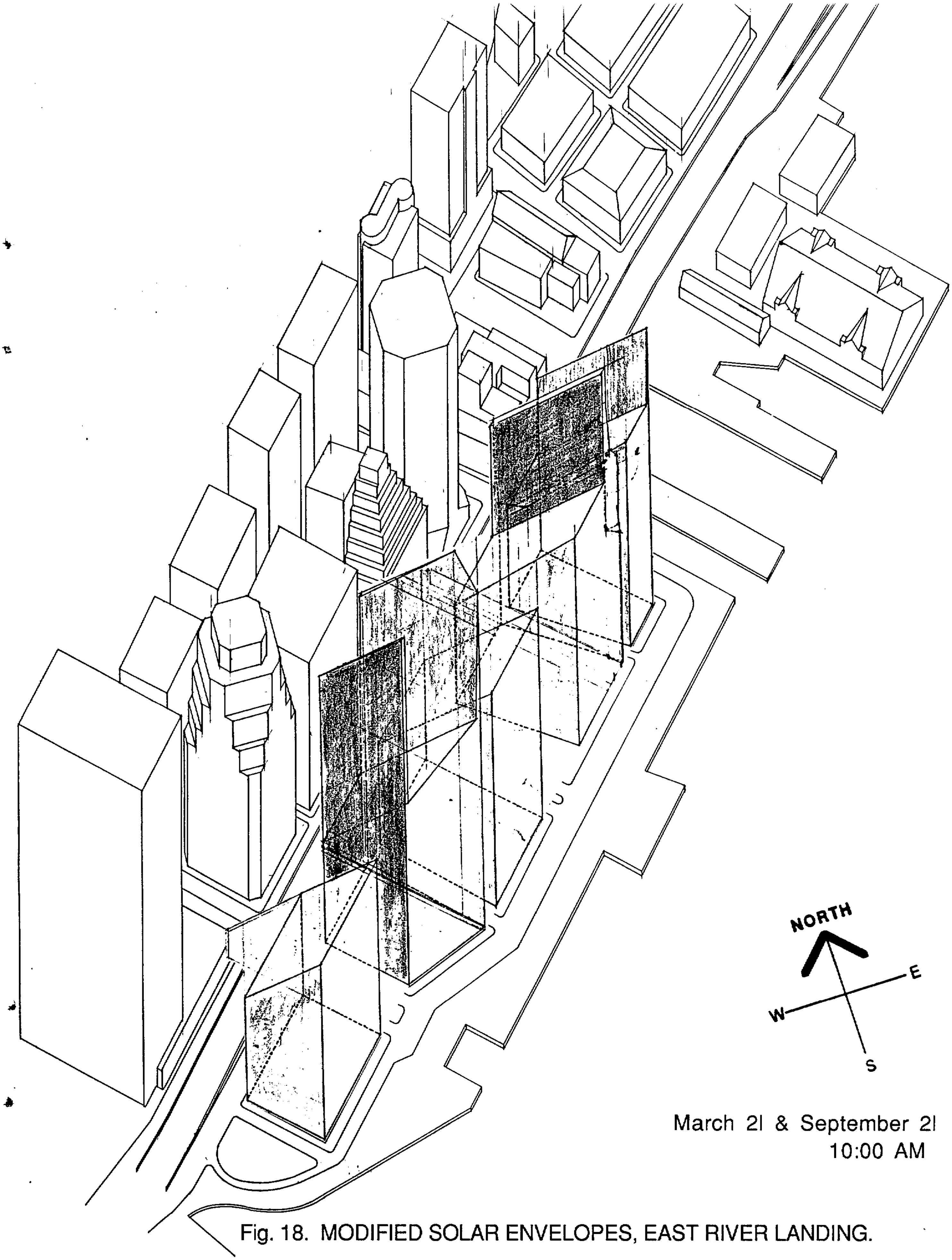


Fig. 18. MODIFIED SOLAR ENVELOPES, EAST RIVER LANDING.

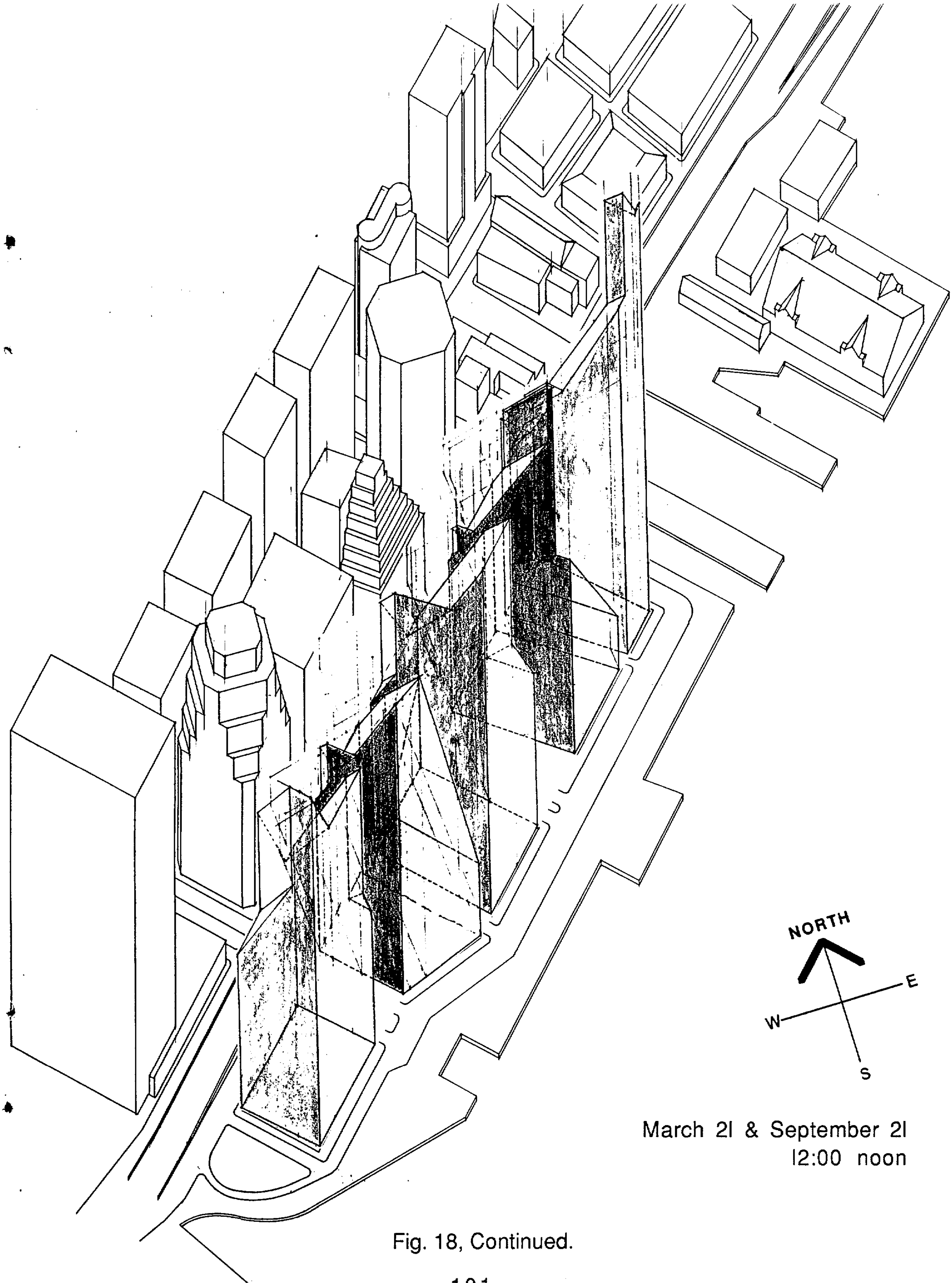


Fig. 18, Continued.

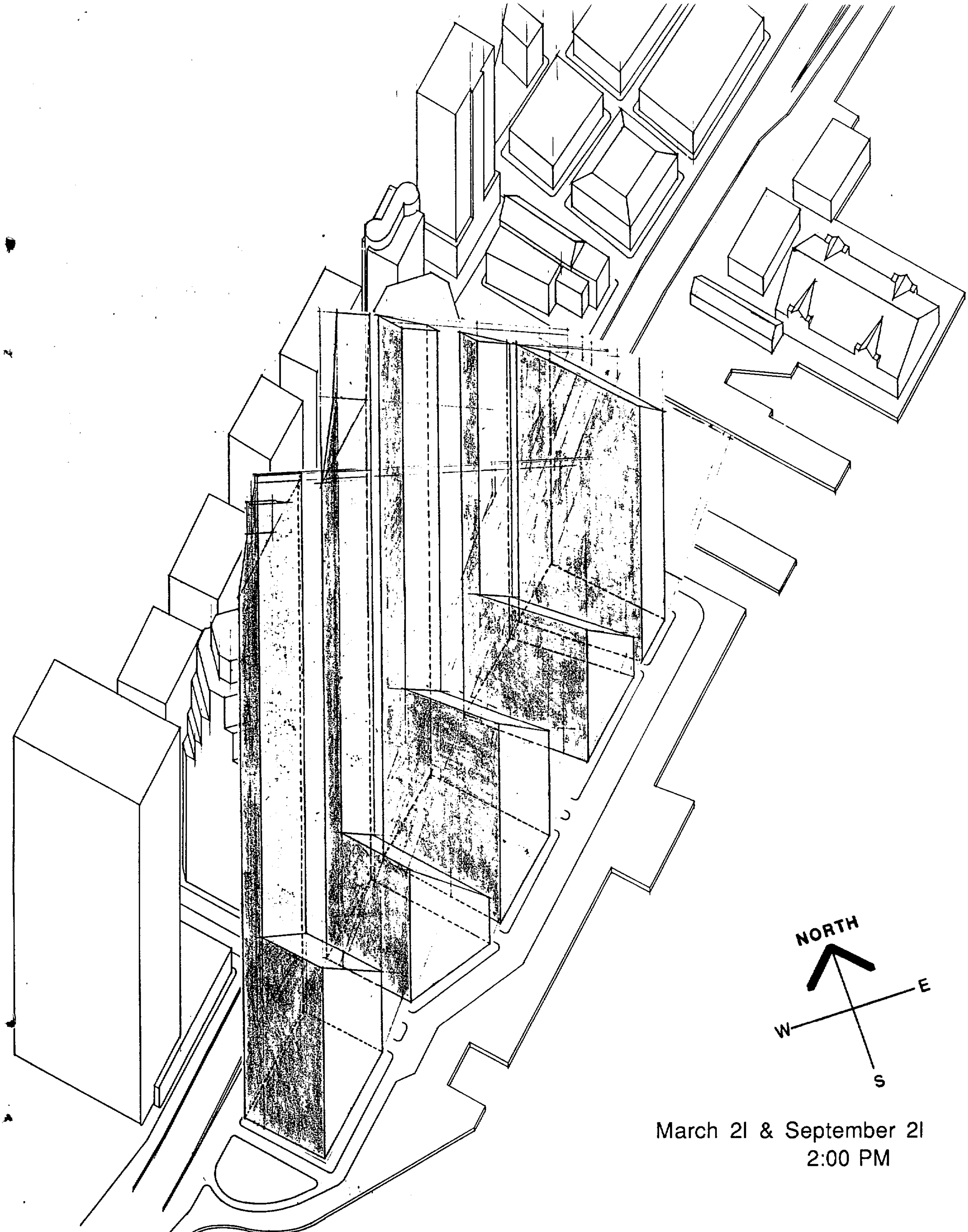
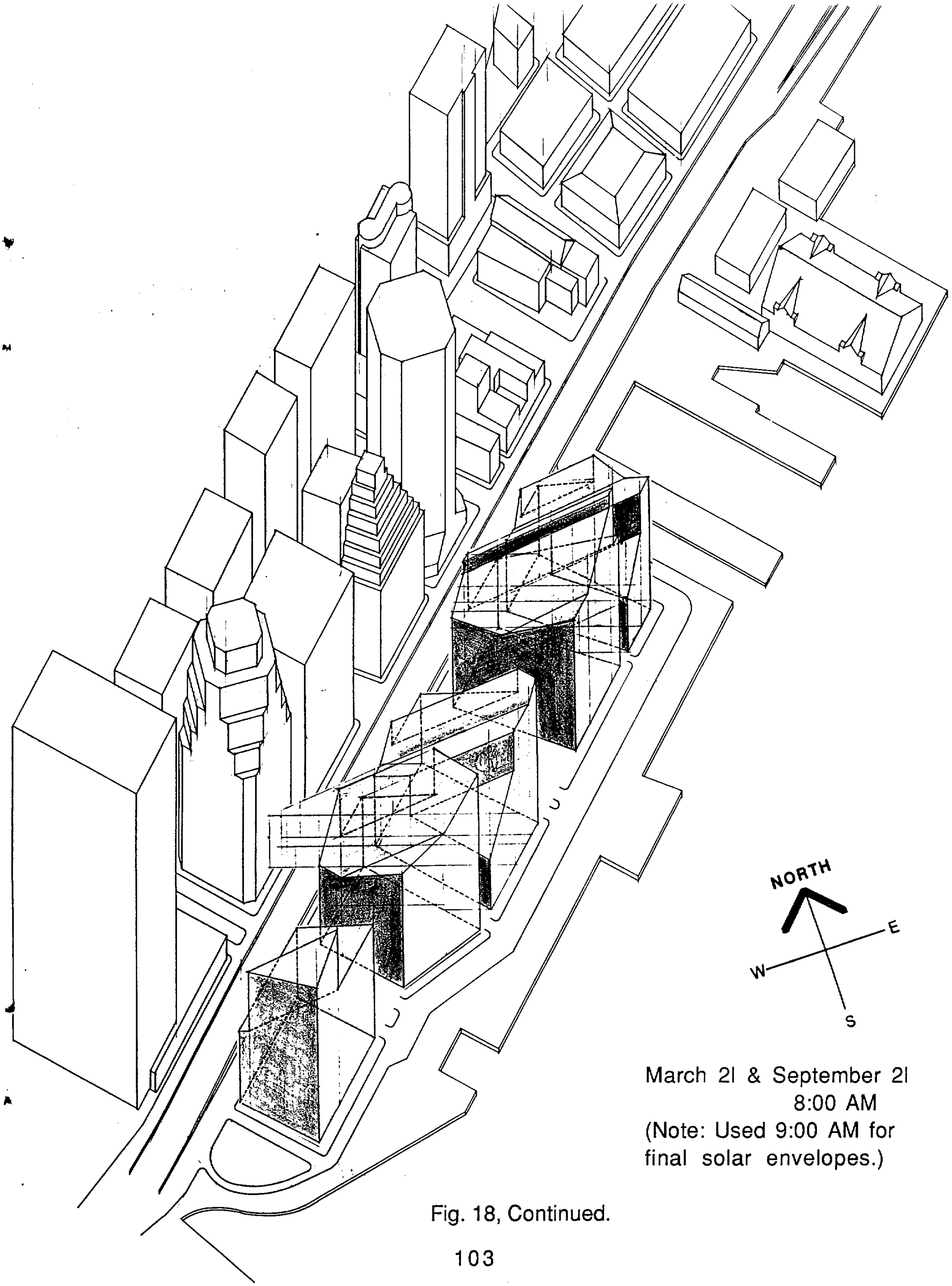


Fig. 18, Continued.

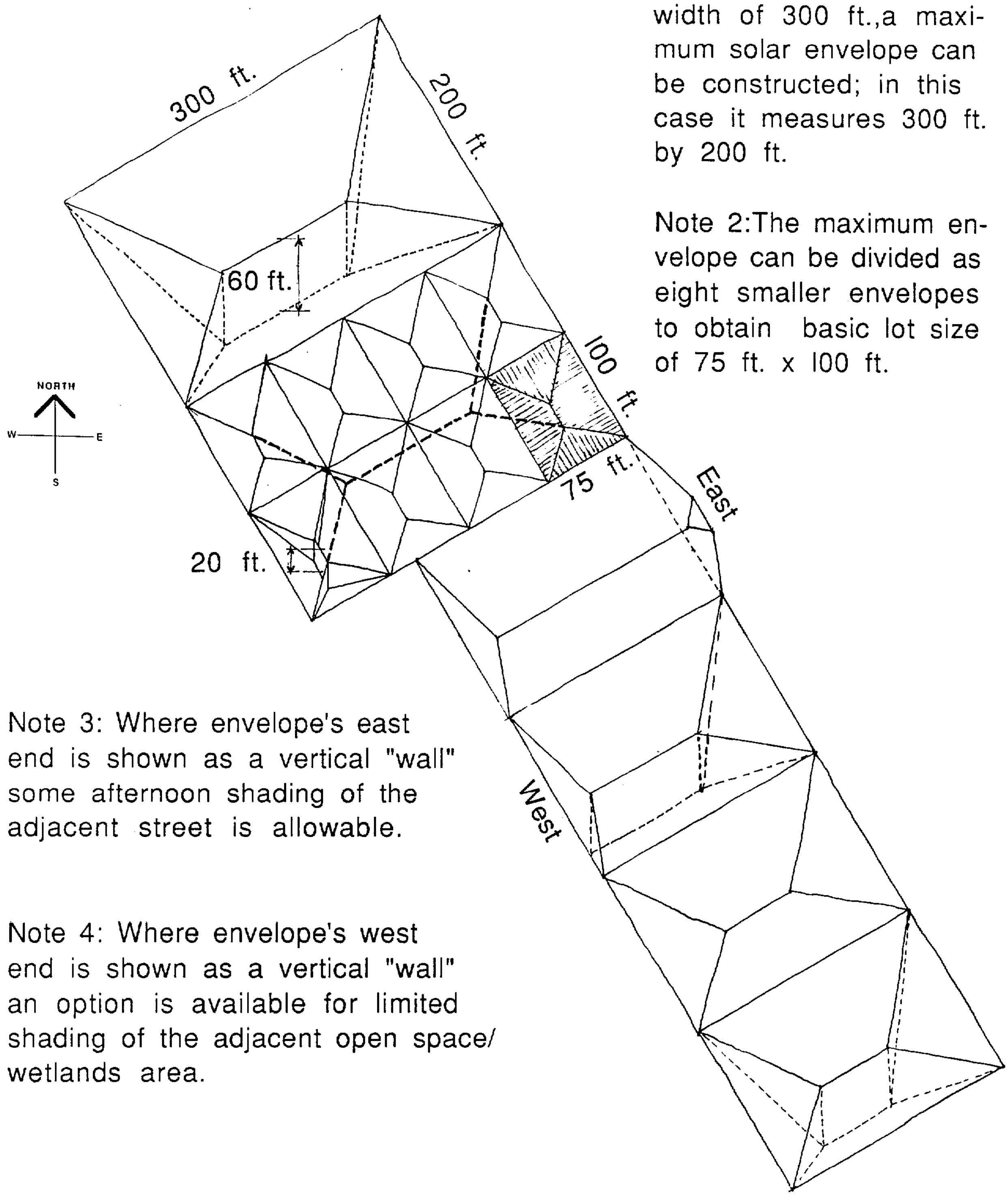


March 2l & September 2l
8:00 AM
(Note: Used 9:00 AM for final solar envelopes.)

Fig. 18, Continued.

Note 1:Since this part of the site has a maximum width of 300 ft.,a maximum solar envelope can be constructed; in this case it measures 300 ft. by 200 ft.

Note 2:The maximum envelope can be divided as eight smaller envelopes to obtain basic lot size of 75 ft. x 100 ft.



Note 3: Where envelope's east end is shown as a vertical "wall" some afternoon shading of the adjacent street is allowable.

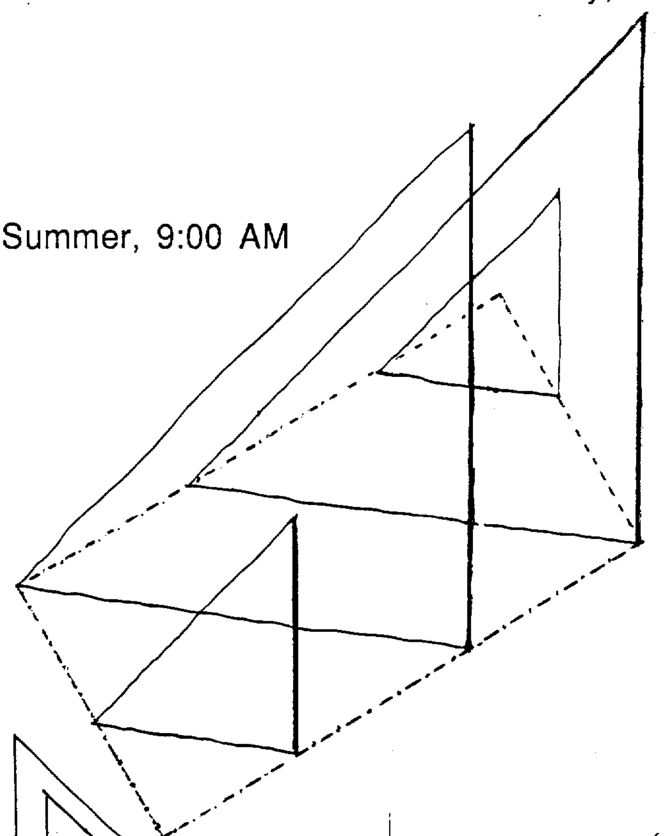
Note 4: Where envelope's west end is shown as a vertical "wall" an option is available for limited shading of the adjacent open space/ wetlands area.

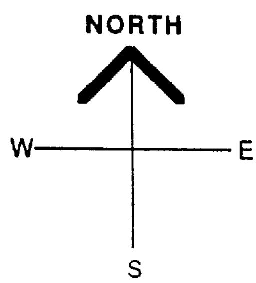
maximum width of site is 300 ft.

Fig. 19. SOLAR ENVELOPES, ANNADALE-HUGUENOT, INCLUDING DIVIDING LARGER SOLAR ENVELOPE INTO SMALLER ENVELOPES.

The solar envelope for the east part of the Annadale-Huguenot site was constructed in accordance with procedure developed by Ralph Knowles (See bibliography.) but adapted by the study team for use in New York City, as follows:

Step 6 (See Steps I-5.) Positioning morning and afternoon triangles (each triangle formed in Step 5 by the hypoteneuse of the solar pole & azimuth line)





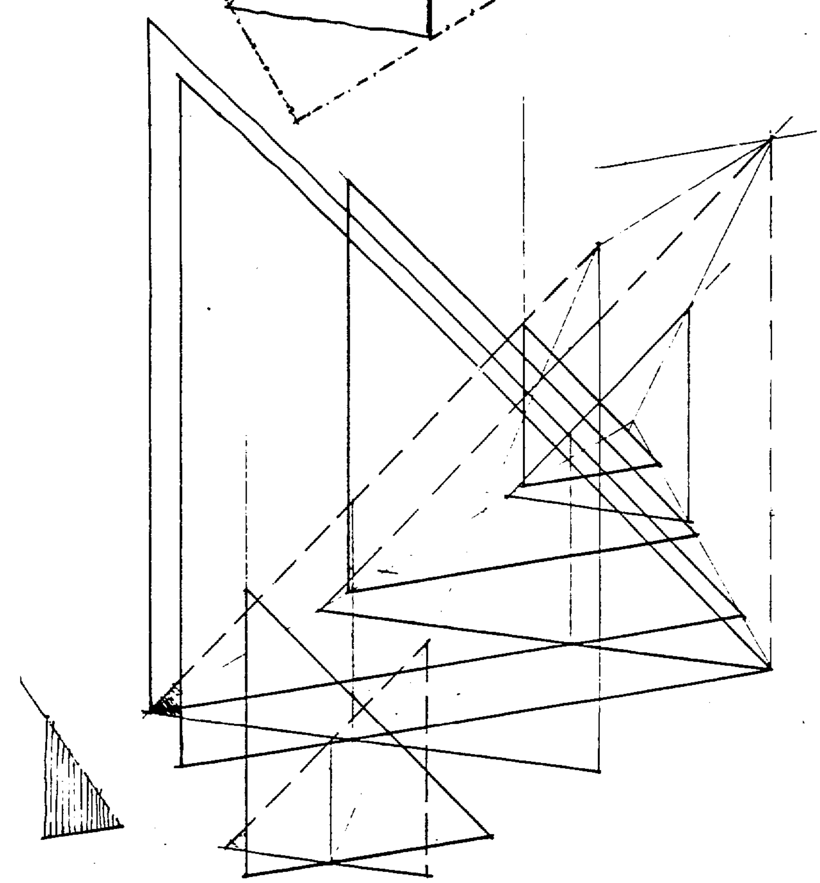
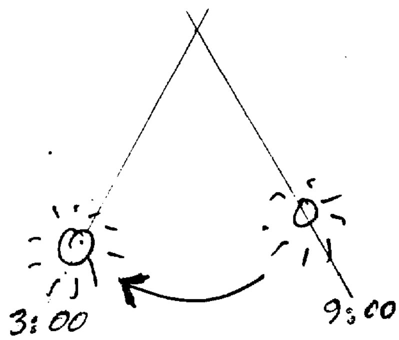
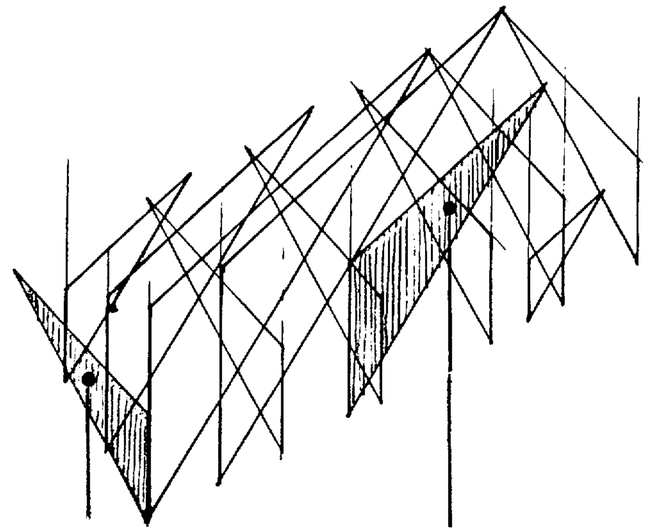


Fig. 19. Summer, 3:00 PM

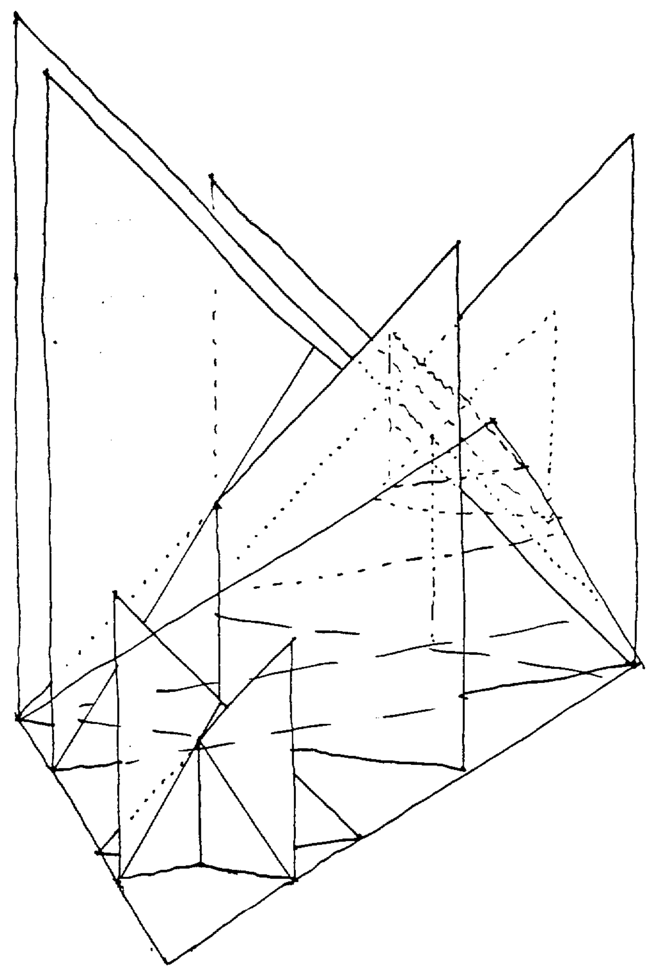
Step 6, Continued





Winter, 9:00 AM Winter, 3:00 PM

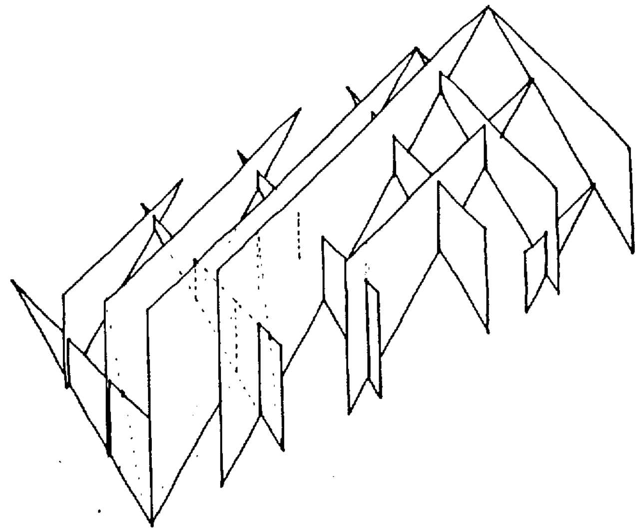
Step 7
Intersecting afternoon and morning triangles to find redundancies (parts of the triangles which shade each other)



Summer morning intersects afternoon

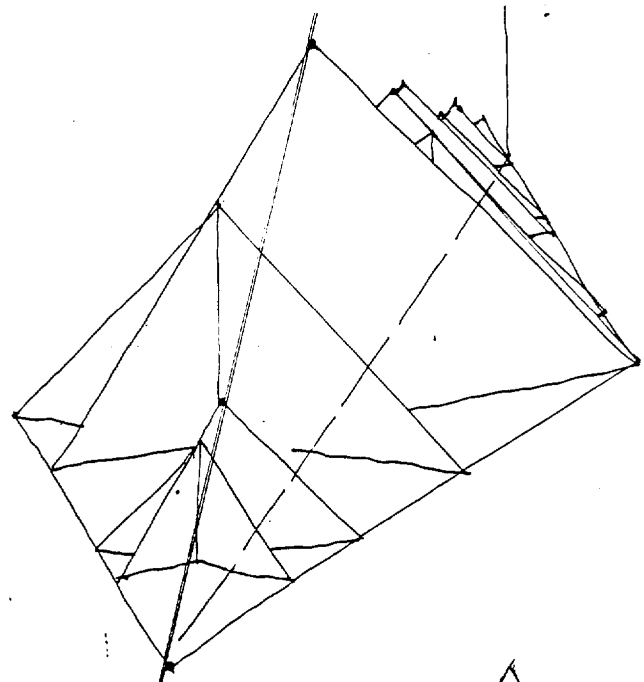
Fig. I9, Continued.

Step 7, Continued



Winter morning intersects afternoon

Step 8
Eliminating redundant parts of triangles after their intersection



Summer

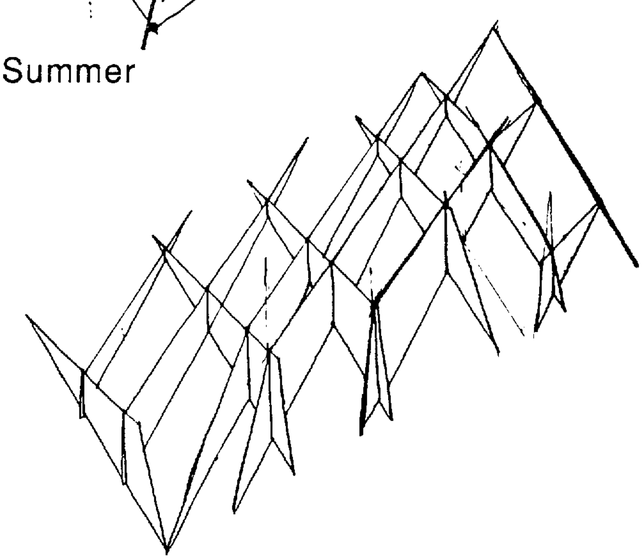
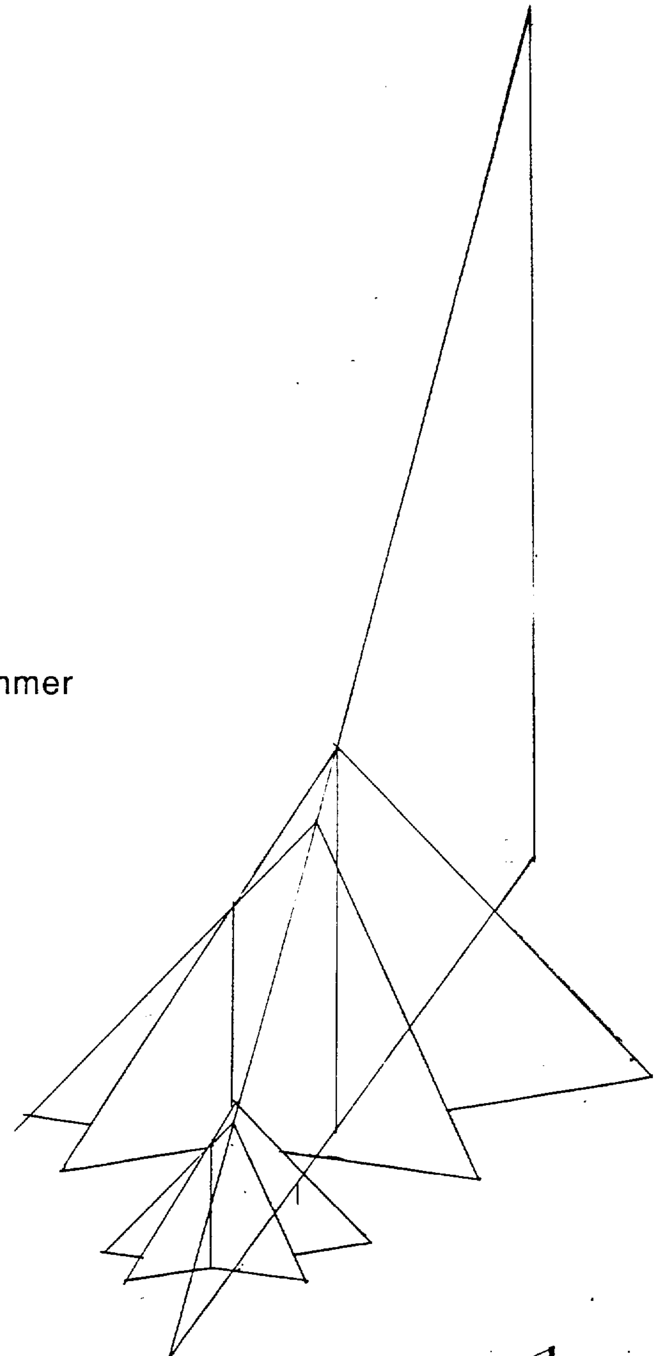
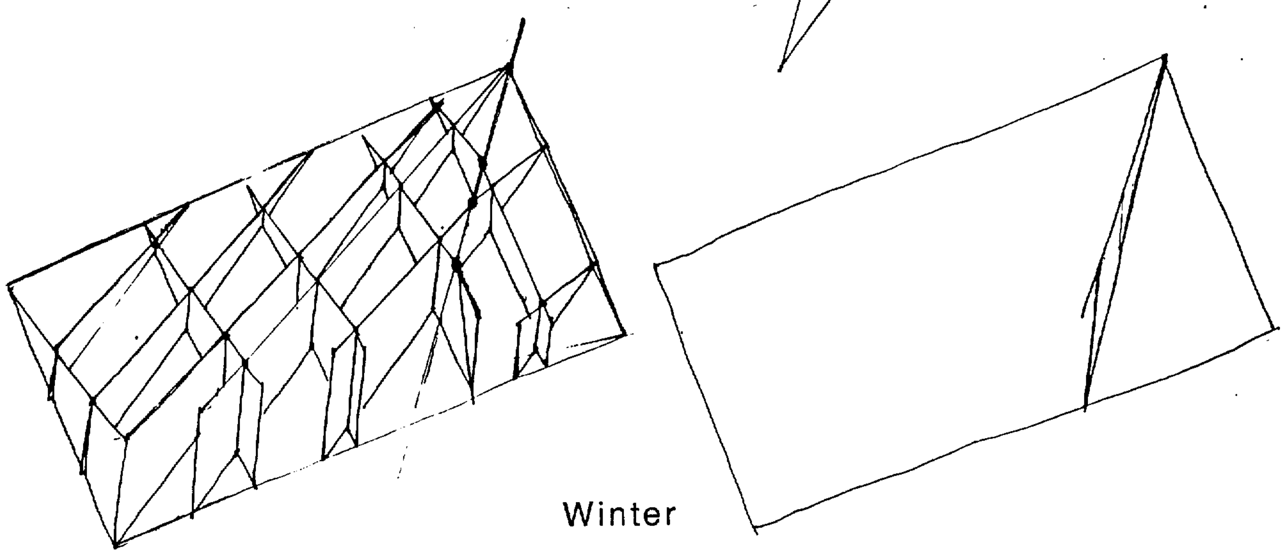


Fig. 19. Winter

Step 9
Establishing the hip lines
and expressing each hip
as a triangle

Summer





Winter

Fig. 19, Continued.

Step 10
Intersecting the summer hip triangle with winter morning triangles from Step 6

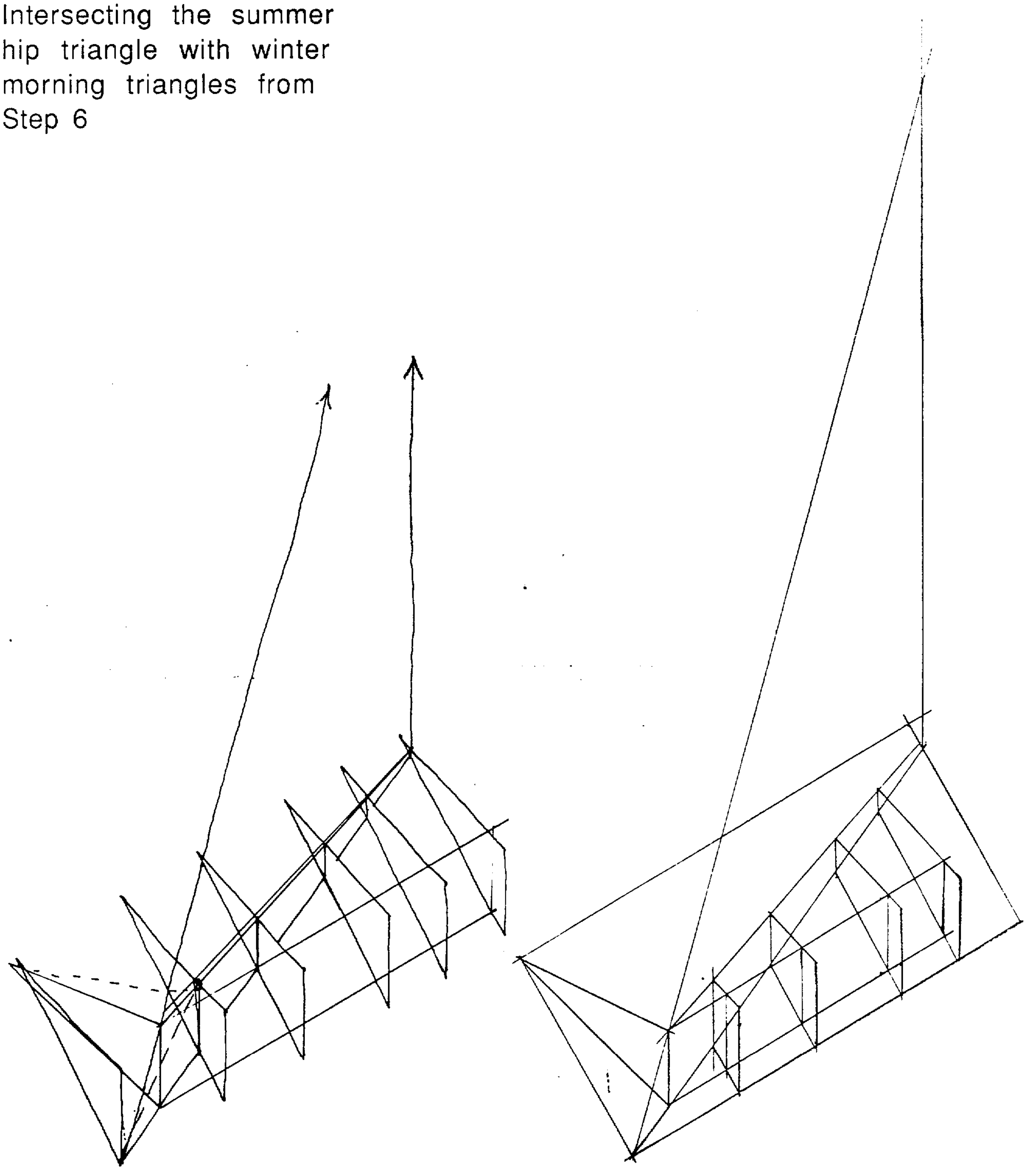
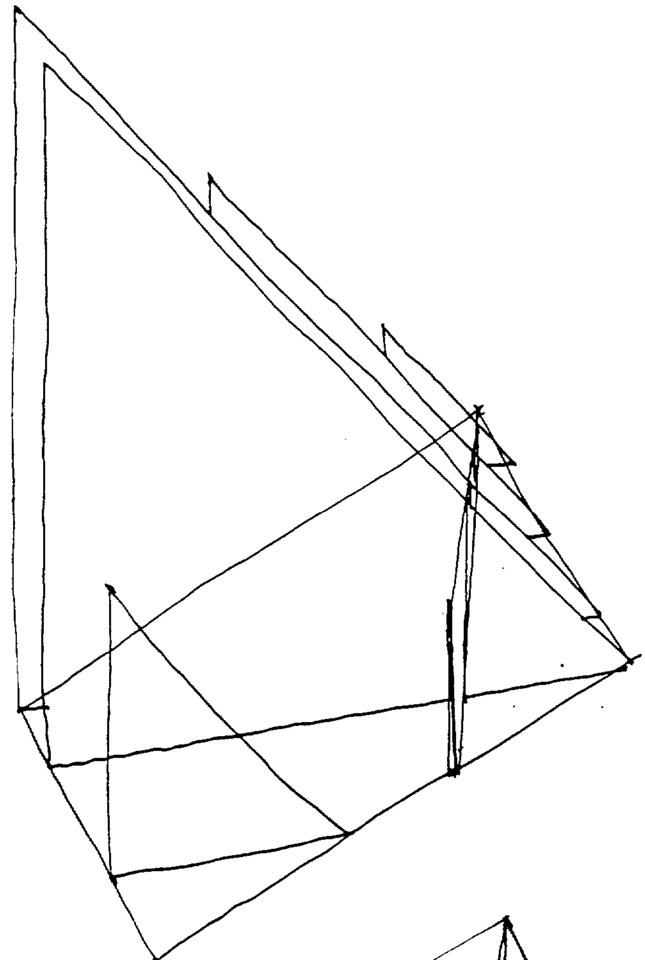
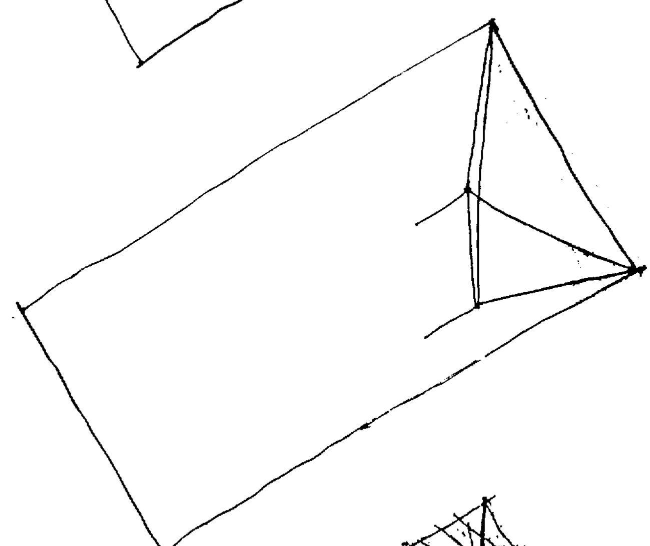


Fig. 19, Continued.

Step 11
Intersecting the winter hip triangle with the summer afternoon triangles from Step 6



Step 12
Finding the ridgeline of the resultant solar envelope



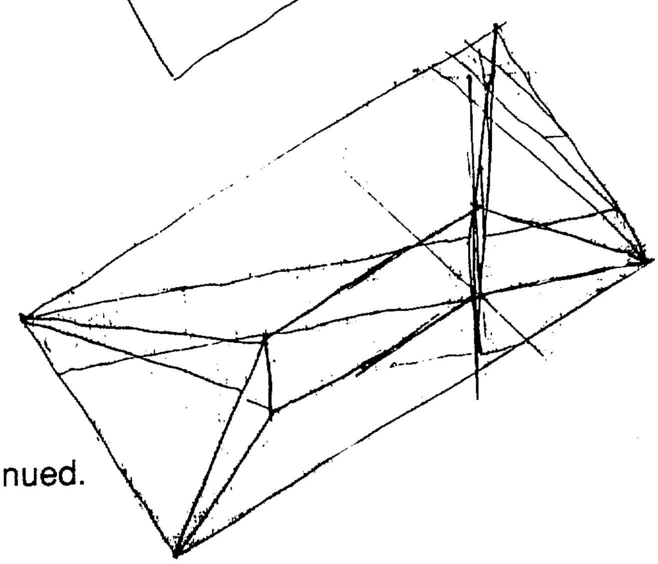
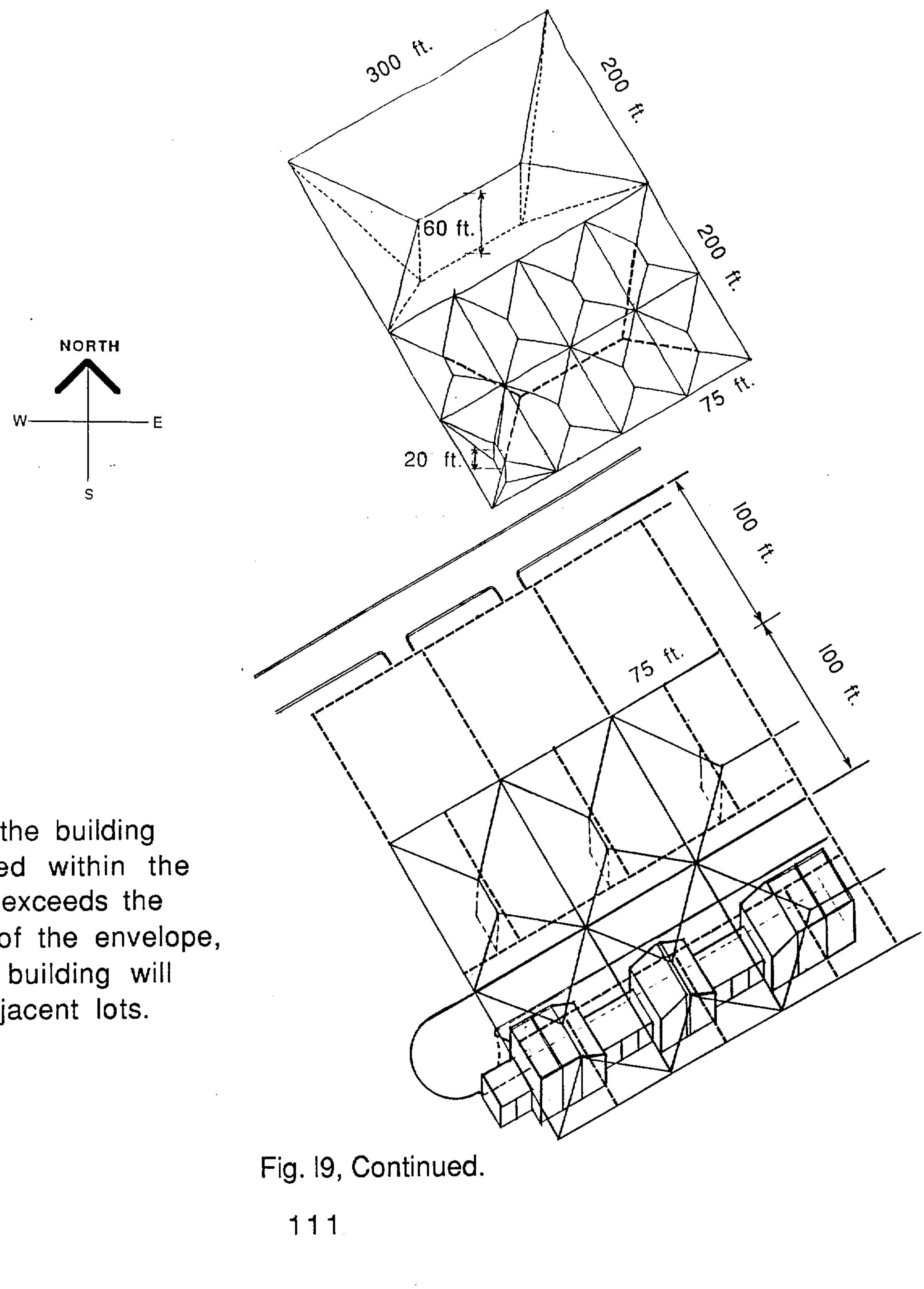


Fig. 19, Continued.

The construction process has yielded a maximum solar envelope for the width of the site (300 ft.). When this solar envelope is subdivided,following a standard mathematical procedure of similar triangles, a basic lot of 75 ft. by 100 ft. is obtained. (The maximum solar envelope, or a "nesting" of eight of these basic lots, measures 300 ft. by 200 ft.) Once the envelope is determined, individual houses or rowhouses can be constructed within the volume subscribed by the envelope , as follows:



Note: If the building constructed within the envelope exceeds the surfaces of the envelope, then the building will shade adjacent lots.

Fig. 19, Continued.